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THE JOURNAL
OF THE
RÖNTGEN SOCIETY.

EDITED BY

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RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Institution of Electrical Engineers on Tuesday, November 7th, 1916, Mr. J. H. Gardiner, F.C.S., President, in the chair.

The minutes of the last meeting were read and confirmed.

The following were elected members of the Society:—

Mr. H. C. SHANNON.

Dr. A. RUSSELL GREEN, M.B., B.A.

NOMINATIONS.

GEORGE VILRANDRÉ, Green Court, Staplehurst, Kent.
Proposed by J. DOUGLAS MORGAN.
Seconded by ROBERT KNOX.

FRANCIS SHILLINGTON SCALES, M.A., M.D., B.C. (Cantab.)., Physician in charge of Electrical Department, Addenbrooke's Hospital, Red Court, Adams Road, Cambridge.
Proposed by Geoffrey Pearce.
Seconded by Robert Knox.

MORTIMER ARTHUR CODD, Electrical Engineer, 32, Halfmoon Lane, S.E.
Proposed by Howard C. Head.
Seconded by W. E. Schall.

MAJOR JOHN WALTER TURREL, R.H.M.C. (T.), M.A., M.D., Consulting Physician in Electro Therapeutics, Cherwell Lodge, Magdalen Bridge, Oxford.
Proposed by C. Thurstan Holland.
Seconded by Robert Knox.

CHARLES E. HOLLAND, M.A., 12, Redington Road, Hampstead, N.W.
Proposed by C. Thurstan Holland.
Seconded by Robert Knox.

JOHN DRUMMOND PRYDE MCLATCHIE, M.B., C.M., 34, Welbeck Street, W.
Proposed by J. E. Harvey.
Seconded by Robert Knox.

Mr. GARDINER said that last November he expressed the hope that the war would be over during the session. That hope had not been realized, but the disappointment was mitigated to some extent by the very successful character of the year's work. In spite of the depression naturally caused by the circumstances of the moment, it was a matter for congratulation that the Society had been able to "carry on," and he was confident that under the presidency of Captain Thurstan Holland the coming session would be equally successful. The name of the President was as well known to all of them as was the name of the Society itself. He had occupied the Chair before (in 1904-5), and they were all pleased to see him back again amongst them.

Captain THURSTAN HOLLAND then formally took the chair, and delivered his presidential address.

PRESIDENTIAL ADDRESS.

IN the first place, I should like to thank you for the great honour you have done me in electing me as your President for the second time. It is an honour which I can assure you all I deeply appreciate, and I shall endeavour to carry out the duties of the position in accordance with the great traditions of the Röntgen Society.

I assume that it will be in accordance with your wishes that I should take this opportunity of expressing the loss that the Society—the

members individually, and the cause of science generally—have sustained by the untimely death of our first President, one of the founders of this Society, Professor Sylvanus Thompson.

I remember him as the first Professor of Physics at the then recently established Bristol University College. As a school boy of sixteen years of age I was amongst the first students there. He was then, in his early days, a man who both lectured and taught well, who took endless trouble and pains to instil into us even the very elementary physics required for the London Matriculation examination; and his kindly manner, added to the fact that, in the true sense of the term, he was a teacher, made him popular with all his students. Years later I met him again at the soiree of this Society held in St. Martin's Town Hall on the evening of Friday, November 5th, 1897. Many of you may remember his brilliant Presidential address, delivered to a large, representative and appreciative audience; a good send off to a society which now for some twenty years has proved its value. It is twenty years since I took my first radiograph, twenty years brimful of interest, and of advances which, in those days, none of us could have even dreamed about, advances which may perhaps be illustrated by the fact that the first successful radiograph I saw taken was that of a hand, and the exposure was 1¾ hours. Almost the last one I took myself was one showing a bullet with its point sticking into the posterior surface of the heart in the midline of the body. A direct lateral view was made so rapidly that the shadow of the bullet (which was never still even for a fraction of a second) is quite sharp.

A Presidential Address is a serious matter, but whether it is a more serious matter for the President than for the members who have to listen to it is a moot point. At any rate the President has certain advantages—he can inflict what he likes upon his audience, and take as much time as he pleases.

In thinking over various questions which might form the basis of an address I finally decided that one might suitably make some remarks on the status of Radiology and Electro-therapeutics, the status of those who practise these branches of Medicine, and on what naturally follows, the teaching of these subjects.

What has perhaps influenced me more than anything else in the choice of subject is the effect that this war has had on radiography and those practising it. What I mean by this is possibly best illustrated by two or three examples.

1. We have the fact that at the beginning of the war the X-ray department of a large military hospital was put in charge of an unqualified (that is, of course, a gentleman with no medical qualifications—and please understand that in the course of my remarks if I use the term "unqualified" it always means one having no medical qualification), having an officer's commission, and he had working under him a duly qualified medical man well up in X-ray work. However eminent in his own line, and he is an eminent physicist, that he should be the chief of a department directing a qualified man in his medical work, is preposterous. Such an arrangement should be an impossibility.

2. Two assistants in a physics laboratory were sent to the military hospital to which I am attached with orders for facilities to be given them to learn X-ray work. Their knowledge of medicine was, of course, nil. They came to my department for a few hours a day for a week. Shortly afterwards I had letters from them thanking me for the instruction, and informing me that they had been given charge of X-ray departments in large hospitals. Comment is unnecessary.

3. An elderly medical man came to me, from a hospital ship being fitted up in Liverpool, asking for instruction in X-ray work, as he was to have charge of this work on the ship. Practically he knew nothing about X-ray work, so I enquired the reason of his appointment. The reply was "Oh, the C.O. called the officers together, allotted them their duties and informed me that I must do the X-ray work."

Incidentally I may add that the ship was equipped two days before she sailed by a well-known London X-ray firm; I was telephoned for to go and see the apparatus. It was beauti-

ful, it must have cost a very large sum of money, it was most elaborate, and I can honestly say that I did not know what some of it was for or how to use it. Amongst other things was a large quantity of 15 by 12 X-ray plates—you know what they cost—and I am perfectly certain that not one of them was ever used. If any qualified expert had had the fitting up of this ship the country would have been saved a considerable amount of money and, and this is of more importance, would have had a practical set of apparatus on board.

Similar occurrences to those I have related could no doubt be multiplied over and over again. The results of such practices may be summed up and illustrated by quotations from papers and by the recording of what is common knowledge.

As bearing on this one should remember that from the X-ray point of view there are two classes of medical men unacquainted with X-ray work :—

1. Men who recognise to the full the value of radiography as carried out by, and interpreted by, those who have made themselves into specialists on the subject, and, knowing nothing about radiography, rely upon the expert's opinion.
2. Others who believe they intuitively know all there is to know about radiography, and who believe that no trained skill or experience is necessary to read a radiograph for diagnostic purposes.

Now recognising these two classes of medical men unacquainted with radiography, one result of bad radiography (*i.e.*, unskilled or unqualified radiography) on the latter class is mistakes of interpretation, mistakes in localization, belittling the value of radiography, and rash utterances in various publications. For example, in a discussion on X-ray work in France in the early part of the war one surgeon is reported as having said "that he did not consider any existing method of X-ray localization as of really any great value to surgeons." Another surgeon has definitely published the following :—"If *after* operating I failed to find the foreign body I then availed myself of the help of X-ray plates." A third observation I came across is as follows :—"A skiagram, after a bismuth meal, was taken and the position of the stomach was seen to be midway between the umbilicus and the pubis."

The two former are excellent examples of the state of mind brought about either by unskilled radiography, by radiography carried out by non-medical men, or by surgeons without knowledge interpreting their X-rays for themselves.

The third, describing the stomach as being situated between the umbilicus and the pubis is, of course, pure unmeaning balderdash.

In addition many of us know that as a result of X-ray work being carried out by unskilled and untrained operators, there have been a number of burns inflicted upon wounded soldiers, either in the course of X-ray examinations or in the course of removing foreign bodies under the screen; and also that some of the operators have themselves been burnt—a return to the conditions of the early days of X-ray work; but then we knew not the risks and how to guard against them; now the cause of danger and the conditions of safety are well known.

Further, as showing the risks to patients when there is the combination of a rash surgeon and an unqualified radiologist, a striking example came directly under my own observation, and is merely one of many similar, but not so sensational, cases I have seen. The case I allude to was a wounded soldier brought home on a hospital ship from the East. His anterior chest wall over the region of the heart bore the mark of a large operation wound—the incision a good 4 inches in length—the bullet, for the removal of which the operation had been planned, as a matter of fact was about 1½ to 2 inches deep in the muscles of the back. An X-ray apparatus had been installed upon the ship, but unfortunately no one was competent to use it.

To multiply these examples is needless, those I have quoted fully illustrates the main point at which I am aiming, namely, to emphasize the bad effect on everybody interested which

untaught and unskilled work must inevitably bring about, and further to emphasize the point of the danger that one result of this war may be that a very large number of non-medical men and women will attain a certain amount of knowledge of radiography, and a large number of medical men will be imbued with the idea that no training is required either to take successful radiographs or, and this is of even greater importance, to interpret them.

In the early days of this Society, which means in the early days of X-rays, much valuable work was done by non-medical men. I do not allude to research work and such like, but much actual radiography was done, often by instrument makers and chemists, but also by a few whose technical knowledge of physics and electricity helped them in the management of the apparatus. What I mean is that the X-ray examination of medical and surgical cases was undertaken by such workers. Now, without wishing in any way to under-estimate the work which was thus accomplished, I maintain that the time for that sort of thing has gone by. In those early days there were few medical men with the technical knowledge necessary for successful X-ray work. In those days the chief desideratum for some time was a good plate; this, although of great importance at the present time, is nevertheless nothing when compared with the real essential for an X-ray expert, namely, interpretation. The former, the good plate can now be obtained by anybody, with modern apparatus, with very little training; the latter, interpretation, can only be done by a medical man of unusual professional attainments, who has given years of close study to a very difficult subject.

Whilst on this point of the non-medical X-ray practice for gain I should like for a moment to digress to call attention to what, in my opinion, is a very deplorable fact, namely, that there is a distinct tendency amongst certain surgeons and physicians to send their X-ray work to unqualified people. This is more especially the case in London, and to my certain knowledge it is done by eminent members of the medical profession.

At the present time when nearly every large hospital in London has attached to its staff a medical expert, and when practically all these men are trying to earn their living at X-ray work, it seems to me to be a very anomalous state of affairs, to say the least of it, that physicians and surgeons on the staff of such a hospital should not hesitate to use the hospital X-ray department and expert for their hospital work, but should send their private work to a non-qualified man.

The reason for this is most certainly not because the work is better done, although this is, I understand, one of the reasons which has been used as an excuse. I believe the true reason to be that certain gentlemen do not desire expert X-ray opinions, but wish to give their own interpretations of the radiographs to their patients, and thus avoid the possibility of any friction of opinion which might or might not be of benefit to the patient. This support of non-qualified medical work is not, in my opinion, in the best interests of the profession.

To resume. I said that X-ray interpretation required a man of unusual professional attainments, I should qualify this to a certain extent by saying that the real X-ray expert must necessarily be a man of unusual professional attainments. Why do I say this? The answer to it is seen by what goes on every day in the well-equipped radiographic department of a large hospital. The man in charge must have a thorough knowledge of physics, chemistry and electricity. He must be to a certain extent an electrical engineer. He must be a very expert photographer, he must be a good organizer, he must have more tact than most people if he is to run the department without constant friction with other members of the hospital staff—perhaps I might venture to go as far as to say that tact is one of the most important of all the qualifications, but all this is really nothing when it comes to the medical qualifications which are requisite. Consider the cases which are treated by X-rays. They range from ringworm and a large number of skin diseases to glandular affections of various kinds, many systemic diseases, and last, but

not least, the various forms of malignant disease. An intimate knowledge of all these is absolutely necessary if the treatment is to be carried on in a scientific manner. That is, our expert must be able to discuss skin cases with a skin specialist and medical cases with a physician. He must know his anatomy very thoroughly indeed if he is to answer all the questions which will crop up in his surgical work, the anatomy of bones at all ages, the general anatomy of the entire body—this latter point having been accentuated of late by the necessity for the accurate localization of so many foreign bodies. He will not be able to put the proper interpretation on many plates if he is not well up in the pathology of practically all diseases, inasmuch as he has to know the conditions which are caused by various diseases and fit these in with what is found to be X-ray abnormal. It is obviously of no use to show an abnormality of, say, a chest, unless an accurate knowledge of the various diseases which could—and also could not—give rise to such an X-ray abnormality is possessed.

I do not wish to labour this point but I think it is clear that the radiologist must be well up in surgical and medical diseases, and possess more than a little knowledge of most special diseases. The practice of X-rays covers such a large field at the present time that fractures, bones and their diseases, the location of foreign bodies and so on form but a small part of X-ray work. When we come to sinus work, to the examination of the Thorax and its contents, to the differential diagnosis of kidney stones and other shadows, to say nothing of numerous other things, it must be obvious to all that the expert radiologist, to be successful, must be, as I have already said, a man of unusual professional attainments. In the picture I have drawn up for you, you will see that in a hospital X-ray department it is becoming more and more of a necessity that the X-ray expert —who always has his medical and surgical colleagues to consult with—should have to assist him trained assistants to carry out the more or less routine part of the work. There is, and can be no objection to these assistants, male or female, being taught to take plates, to administer doses of X-rays, to carry on routine work, but, and this to my mind is of paramount importance, no opinion should be given by such assistants, no treatment carried out on their initiative, and the head of the department should hold all the strings very firmly. Further, if this is essential in a hospital department, how much more essential should it be in outside work, that no one should be allowed to practise this speciality for gain, unless he or she is duly in possession of a medical qualification. In hospital work it is always possible to get valuable help from colleagues on the staff, in private work one must rely upon oneself entirely.

Let us for a moment consider what the present condition of radiology is in this country. I will begin by pointing out that, undoubtedly the X-ray department is the most important single department in any hospital. In a general hospital in which the department has been allowed to reach its full development, and in which the man in charge has been well supported by the rest of the staff, it is not too much to say that the cessation of its work would paralyse the work of the whole hospital. The out-patient diagnosis of fractures—as carried out by senior students—would cease to be an exact science. The surgery of kidney stone would no longer exist. The certain diagnosis of a large number of conditions affecting the Thorax—for instance, the early diagnosis of aneurism—would not be possible. The exact diagnosis of stomach conditions—inasmuch as an X-ray examination is essential for the knowledge of many facts in connection with this organ—would return to the condition of pre-X-ray days when a diagnosis of Atonic Dyspepsia covered a multitude of sins. These are merely examples of what would happen. Recognise these facts. What is the present position of most men in charge of X-ray departments ? What are considered to be the qualifications in a large number of cases which the man who is put in charge should possess ? Often—too often—the post has been given to anyone who would take it. Often—and again

too often—it has been given to a man who has not been considered quite good enough (in the opinion of the authorities) for other hospital posts. It says much for these men generally that many of them have risen to become recognised authorities in their work, many have become well known in the world of medicine, often far better known than others considered more worthy of so-called senior posts.

Another point. Taking the large teaching hospitals of this country, how many of those in charge of X-ray departments are full members of the staff with the privileges of such a position. Singularly few. Many have no position whatever as members of a hospital staff; many are paid small honorariums—not from feelings of generosity—but so as to ensure their being kept in a very junior position. Unfortunately this is largely due to the attitude of physicians and surgeons holding full staff appointments. I know of one large provincial hospital in which the brilliant chief of the X-ray department—a man whose name is well known for original work all over the world—is paid a small honorarium. His lay committee—lay, mark you—recently suggested that he should be promoted to full staff appointment. A physician as representing the medical board, a man whose name is not, and will never be, known outside his own town, and is not perhaps particularly well known even there, opposed this tooth and nail. I cannot say how much of his opposition was as representing the medical board, or how much merely personal, but I understand that he had the impertinence—for it was an impertinence—to suggest that instead of making the head of the department a full member of the staff, it would be better that one of the honorary physicians or surgeons, already a full member, should be made the titular head of the X-ray department.

As a contrast to this it may be of interest to quote from the celebrated surgeon Willy Meyer, of New York (*Medical Record*, Dec., 1915, p. 1079). Writing of radiologists he says, "In general we rarely meet a class of colleagues who are, as a rule, more careful and reticent in rendering a definite conclusion on the basis of their examination."

Peter Harding, in that altogether delightful book "The Corner of Harley Street," said of a bacteriologist or pathologist—it was before the days of X-rays or I am sure he would have included the radiologist—"For though as a profession, we must needs lean each year more heavily upon the skilled workers at our right hand, yet at present we are all very reluctant to give them their full dues either in professional éclat, or in pounds, shillings or pence. All the same their day is coming." But if, ladies and gentlemen, we are not appreciated as we should be by the profession, this, at any rate, is not the case as regards the general public.

Let me tell you a little anecdote against myself. I had been examining a wounded soldier with the screen for a possible foreign body. One was present, and it was duly localized, the whole operation being a screen one. The lights were turned up, and I proceeded to my desk to write the report. The Sister came up, and I noticed that she was smiling in a curious manner. The answer to my request for information was as follows:—"Oh, the Tommy asked me who you were, Sir, and when I told him, he said, 'Eh, Sister, he must be a very clever man, if he could see all that in the dark; what would he have seen if the light had been up.'"

To resume. If it is true, and I believe it is, that the large teaching hospitals of this country do not take a sufficiently serious view of the importance of the position and education of the head of an X-ray department, what can be expected from the more numerous, but equally important—from the patients' point of view—smaller hospitals which exist in almost every town in the kingdom. At the present time large numbers of these are equipped with X-ray installations, many very inefficient, some very good. Almost without exception I may truthfully assert, that those who do the X-ray work in these hospitals are either medical men without special training or knowledge, or else nurses, dispensers and other people who have not had

proper training, even in the technique of working the apparatus.

How, as a rule, are these hospitals equipped ? By experts ? No, the usual routine is that some rich person finds a sum of money for the apparatus : certain members of the professional staff and the lay committee consult various instrument makers ; finally they become enamoured with the apparatus of a certain firm, this firm draws up a specification of what is required, this is accepted and the apparatus is installed. Then, and probably only then, does it occur to those interested that someone must be found to undertake the work. Perhaps a medical member of the staff volunteers, just as often the dispenser, a nurse or some other unqualified individual starts on the work.

The faults of, and the remedies for, such a system are obvious. In the first place, each individual firm of instrument makers is interested in supplying its own special line of goods, and of course does so. If an expert in radiology were equipping a department he would draw the best from various makers and so assemble an efficient whole.

The remedies for the second condition—that is, the inefficient working of the department—I shall deal with later on, but before doing this allow me, by means of illustration, to point out the dangers of the present position of affairs.

Jealousy between hospitals, and the staff of hospitals is such, that even in a large city like Liverpool, in which the Royal Infirmary is well equipped with apparatus, has a complete and very efficient lay staff, and myself and my partner, Dr. Oram, control everything which goes through the department, and in which other large hospitals are similarly situated, no smaller hospital or institution would for a moment think, if it possessed an X-ray outfit—efficient or otherwise—that it should not undertake the responsibility of certain X-ray cases, but should refer them to be properly dealt with. No, rather than that this should be done, if a patient comes to such a smaller hospital, the X-ray examination must be made and acted upon, however inefficiently it is carried out. What is the result of this ? Tragedies ! I have myself seen a case of a child a few months old who swallowed an open safety pin. The X-ray examination was made at a certain hospital and a plate taken by a medical man who had never been taught anything about radiography. On the strength of this examination, the stomach was opened to remove the pin which was not there, it was in the Œsophagus at the level of the root of the neck. Later on I saw the plate, on the evidence of which the stomach was opened ; there was not the slightest shadow suggesting the presence of the pin, and that which was pointed out to me as the possible shadow was a perfectly obvious plate flaw. The child died.

I saw only the other day a boy who was supposed to have swallowed a coin sixteen days previously. He was ill—very ill—with obvious clinical symptoms, yet the father assured me that he had been to a local hospital, the boy had been X-rayed there, and he had been told positively—as a result of the X-ray examination—that no coin was present. The coin, however, was in the Œsophagus at the level of the bifurcation of the Trachea ; it was removed and the boy recovered—it might well have been another tragedy.

Now if instances of this kind can happen in the easiest of all possible cases, what must be going on in such hospitals in all the other numerous conditions dependant upon successful radiography, conditions not so obvious to the lay public ?

I do not hesitate to say, from my own personal knowledge of what is going on, that, far from being a boon to patients generally, many hospital X-ray installations, worked as they are, by either untrained medical men or by equally untrained non-medical persons, it does not matter very much which, are a standing danger to the community, and that the good they do, and the information they yield in a certain number of cases, is far more than counterbalanced by the mistakes made, and by the reliance placed on X-ray examinations and the opinions deduced from them which are hopelessly wrong.

What is the use of being able to take a plate

of an obvious fracture, I mean obvious without any X-ray examination, in which the treatment and results may, or may not, be improved by the possession of such X-ray knowledge, when on the other side of the page is a missed kidney stone and a patient suffering unrelieved for years as a consequence ; or an error in diagnosis as to the position of a swallowed pin and a consequent death ? No, the time has come to enter a strong protest against the continuance of methods which allow of such anomalies to exist.

In no other department of medicine and surgery would such a condition of affairs at a hospital be tolerated for a moment. The pathological or bacteriological work is referred to men trained especially to carry it out. It is not considered that the mere making of microscopical slides, or of cultivations, is all that is necessary—both can be done by laboratory assistants—but the chief of the department must be in a position to give a qualified expert medical opinion as to the bearing of the work he controls. An oculist to a hospital is specially trained, the same applies to the skin, throat or ear specialist.

The pioneers of these special branches of work had to fight not only for their own positions but also for the positions of their departments, and these had to be won in spite of strenuous opposition from, and tardy recognition from, the pre-existing members of hospital staffs. X-ray men will have to make the same fight for radiology, but they may do it with the certain knowledge that in the end victory must come, and this speciality will also have the position which is its due, the teaching which is its necessity.

(I should like to say, at this point, that my own experience at the hospital to which I am attached is altogether different, and if every chief of an X-ray department had the same consideration, and the same loyal support, from his professional colleagues, and from his lay committee, as I have had, there would be nothing to adversely criticise.)

So far I have said nothing as to "Electro-therapeutics," but all that I have said applies with equal force to this branch of medicine. The great advances made during the past decade in various forms of apparatus, and the equally great advances made in methods of treatment scarcely require that attention should be called to them—they are matters of common knowledge.

Electrical methods of treatment have in the past suffered much from the halo of quackery which has surrounded them. The men into whose hands these methods of treatment fell were many of them, at any rate to a certain extent, charlatans. Now this is largely changed and the electro-therapeutic work which the late Lewis-Jones did so much for, is at many of our larger hospitals being carried on most efficiently, and in the best traditions of medical research, by a number of highly skilled, highly efficient men. Of the value of electro-therapeutic methods what greater proof is required than the knowledge of what these methods have done for the wounded in this present war ; methods which have been brought forward in a remarkable manner by the requirements of the wounded ; and the necessity for trained, qualified medical men to superintend this treatment has become very obvious indeed.

In 1915 at the Radcliffe Infirmary, Oxford, under the direction of my friend Major Turrell, 17,225 treatments were given by various electro-therapeutic methods mainly to soldiers. The enormous yearly increase of this work at this one hospital shows in a striking manner of what value the results are when such a department is directed and controlled by a thoroughly efficient medical man who understands his apparatus, its applicability to individual cases, and whose thorough knowledge of medicine and surgery enables him to apply to each case the individual treatment indicated in a scientific, as opposed to a merely haphazard, manner. I instance Major Turrell in this way because I have seen, and been much impressed by, his methods, and the manner in which his hospital department is carried on, but I have no doubt whatever that there are many others in the country where medical men are doing equally good work on similar lines. The real point

is that this work is becoming of more and more importance in all directions, the different means at our disposal for effecting certain results are becoming more and more varied, the profession generally is recognising the value of such work and the necessity for skilled medical control, and it follows that those who are to exercise this control must have the means of acquiring the knowledge to fit themselves for the work. That is to say, that the teaching must be recognised and regulated.

One cannot draw hard and last lines between X-rays—radium, and various electro-therapeutic methods, they merge into one another. Only in one respect X-rays stand alone, and that is in their diagnostic capabilities. Putting this aside, from the treatment point of view, X-rays, radium and the rest ought all to be under the same roof at any rate. Especially does this apply at the present time to radium. At the Royal Infirmary at Liverpool the radium treatment is controlled from the X-ray department; at Manchester the departments adjoin. The time for separate radium institutions, where this is the one and only method of treatment adopted, has gone by, it is a system which must of necessity lead to abuse.

Now I fear that all this is somewhat rambling and disjointed, but the main idea underlying it all is, I trust, clear.

It is the necessity :—

1. For the proper recognition of radiology and electro-therapeutics, and the teachers of these subjects, at hospitals and universities.
2. For the proper teaching of these subjects by men especially equipped for doing this, and their recognition as University teachers.

In many countries this teaching is being organized and carried out on proper lines; in many countries University Professorships and Lectureships have been given to medical men qualified for such posts. We must not lag behind. Perhaps some of you may think that in the middle of this great war matters of this kind are not of great importance. I do not agree. We have got to prepare for the peace we all look forward to, and no harm can come by the ventilation of certain things asking for reformation and accentuated by conditions brought about by the war itself. America has been moving strongly from the X-ray point of view. In quite a number of Universities and hospitals and colleges are Professors of Radiology and of Electro-therapeutics, and in others lecturers on this subject; and it follows upon this, of course, that there are special courses and special lectures for teaching purposes.

America is by no means the only country in which similar conditions exist.

Teaching requirements may be considered for a few moments :—

1. There are the assistants. That is to say, the non-medical assistants, nurses for the most part but also some males; those who must of necessity carry out much of the actual work in the X-ray department of hospitals, and also act as assistants to medical specialists in their private work. The place of these people, as I have pointed out before, is merely that of assistants. They work directly under medical control, accept no responsibilities of any kind and merely do as they are told. Such assistants require training in the photographic part of X-ray work, in the direction of the management of apparatus and so on; should be able to administer definitely prescribed doses of X-rays, or mechanically administer various forms of electrical treatment, should also be taught to take plates of cases according to a routine laid down by the chief. But they should not be allowed, nor should they be expected, to make diagnoses from plates, to give opinions, to make screen examinations of such parts as chests or stomachs, to regulate the treatment of cases, or in fact do any definite medical work on their own responsibility. The teaching of such assistants is already carried out in most departments of large hospitals from the point of view of the requirements of the individual departments, but it should go further than this. Definite instruction should be given in order that there should be a number of such assistants qualified to take up similar posts at smaller hospitals and other institutions, and it should be possible to certify such people as being proficient in such a way.

2. There is the necessity for post-graduate teaching, and this must be arranged from two points of view. At the present time elementary post-graduate courses are of the greatest importance, as so many of the practtitioners had left hospital before either X-ray work began, or before it reached its present position. There will, however, always be a necessity for this teaching in order that medical men in general practice may have an opportunity of keeping themselves abreast of the times. For many years I found in my work that nearly every case came to me on the recommendation of a consultant; it still is the fact that the large majority of cases come in this way; of late years, however, there has been a growing tendency on the part of the general practitioner to have many of his cases examined from the X-ray point of view before calling in a physician or surgeon. This condition of affairs will, I believe, go on, and more and more work will come in that way as the medical student and so the general practitioner gets more and more knowledge of the possibilities of radiography.

The second-class of post-graduate teaching is of even more importance; that is the provision of means by which the man who intends to specialize may fully study the subject. Up to now practically no systematic teaching of this kind has been available. Here and there a man has been allowed the run of a department, and has been allowed to pick up the work as best he could, generally because he laid himself out to be of some use in the department, but he learns on no system and it largely depends upon himself as to how much he does learn. This entirely haphazard method of instruction should give place to a definitely arranged course of lectures, demonstrations and practical work. Of course, neither X-rays nor electro-therapeutics can be taught entirely by lectures; practical everyday work in a large hospital department must be the basis of the teaching, but lectures and demonstrations should be part of the course, and speaking in a very general way it seems to me that such a course of study ought to extend over a period of at least six months.

3. And now I come to my final problem. This is the medical student. This unfortunate individual is already so over-burdened with subjects, lectures and classes all arranged for examination purposes, that it is said to be impossible to add any more to the curriculum. The answer to this must be that X-ray work has become of such overwhelming and paramount importance that it cannot, and must not, be shelved any longer. The public, and not the medical student, is what has to be considered, and the medical student does not imbibe knowledge on his own account, but because it may enable him to practise as a medical man in a safe and reliable manner; therefore I say it is essential that the student should be compelled to imbibe some knowledge of what is now the most important exact means of diagnosis there is in a large and growing field of diseases, and that as the large majority of students will eventually become general practitioners they must have this knowledge before being let loose upon the public.

The future general practitioner must have, at any rate, enough knowledge of X-rays and electro-therapeutics to enable him to know when an X-ray examination for diagnostic purposes is indicated, when he should recommend to a patient treatment by one or other of the various electro-therapeutic methods. Now it is a well-known fact that the medical student will not imbibe knowledge for its own sake, but only from the examination point of view—of course, this applies to the average student—and unless he has the fear of the examination before him he does not attend lectures and classes. I believe that the time has come when it is essential that a course of Radiology and Electro-therapeutics should be included in the curriculum, and that in the final examination questions upon these subjects should be a possibility. Then the corollary to this becomes obvious: the teachers of these subjects must have recognised standing and position.

I do not intend to labour this point further, and I do not intend to place before you any scheme, but it is, I believe, essential that a

start should be made at some university. This start will, of course, take money. Someone who has been making an immoderate fortune by shipping or by food supply may, if he happens to read this address (I understand it will be eventually published), feel impelled to find salvation by putting some of his gains to this useful purpose, a rather more useful one than that which occurred at the University of Liverpool only a week or two ago, when one of the shipping magnates (I take it that he could not have been aware of the fact that we are at war for our national existence) actually gave £8,000 to endow a chair of "Classical Archæology." I say, the money found, a large university would very soon ask to be allowed to start such a scheme—indeed I can foresee the possibility of competition in this direction. Once started other universities would follow suit.

In conclusion, I am hoping to live to see the time when Radiology and Electro-therapeutics, taught at all Universities and Medical Schools by professors and lecturers, will be carried on throughout the kingdom by well-trained, medically-qualified specialists and by such men and women only.

Dr. JAMES METCALFE said: Ladies and gentlemen, I did not know until a few moments ago that I should have the honour of proposing the vote of thanks to the President this evening, but I do so with the greatest pleasure. I have known Dr. Thurstan Holland by repute for many years, and personally for a considerable period, and as we here are all aware he is a man with the most competent knowledge of the science of radiology.

I should like to say a few words about the subject of his address. It is, no doubt, a little hard in a meeting of this character to give an address like the one Dr. Holland has given us to-night. It may sound in a mixed audience—I mean "mixed" from the medical and scientific point of view—something like special pleading on behalf of the medical profession and its work. But anyone who has considered the matter, I think, will acknowledge that with the enormous development of modern radiology, ranging as it does over every kind of disease and trouble man is heir to, the person who undertakes control of work of this kind must be a fully qualified medical man. There is no doubt whatever that the work that has been done along these lines of X-ray inquiry and investigation by men not medically qualified has been enormous. The scientific work of the scientific man in radiology has been one of the main factors in stimulating the progress that the doctors have taken advantage of. But I must say that I do not see how the diagnosis of all kinds of diseases, —diagnoses necessitating the use of opaque meals, of chest diseases, heart and lung diseases, brain diseases,—can possibly be undertaken by anyone unless he has a competent knowledge, not only of radiology, but also of anatomy, physiology, pathology and surgery and medicine. Dr. Holland has put before us the necessity for the due recognition of the status of the qualified radiologist in the future in connection with the great schools of medicine and learning in the country, and I think it is a matter of very great importance that this Society should give an impetus to thought in this direction. The only other thing I have to add is to thank our President most heartily on your behalf for the most thoughtful and educative address that he has given us to-night. Mr. President, I wish to propose you a vote of thanks for your most admirable address.

Dr. MARTIN BERRY said, in seconding the vote of thanks proposed by Dr. Metcalfe: I have the advantage of my colleague in that I have absorbed such medical knowledge as I possess at the Hospital whose X-ray department Dr. Holland adorns. I feel that we owe him a deep debt of gratitude for setting out the position of the radiologist so definitely. It appears natural to a medical man that the control of an X-ray department should be in the hands of a medically-qualified radiologist. Unfortunately, it appears to some as though *any* medical man is capable of working an X-ray department; that is the point on which Captain Thurstan Holland has had some

very forceful things to say to-night. It may not be out of place to record an incident that happened to me within the last fortnight. A stranger — a medical man — came into the department and called for the plate of a certain patient. Having got the plate, he proceeded to examine it and to make a diagnosis. His diagnosis was so utterly wide of the mark that I ventured at this point to disagree with him. He asked me who I was, and I told him, and pointed out that what he thought to be the edge of the liver was the last rib. "In the hospital to which I belong," he said, "physicians come into the X-ray department and make their own diagnosis." I will not labour the point, but I will only say that I am glad to be associated with Captain Thurstan Holland even in so remote a way as the seconding of a vote of thanks.

The vote of thanks was accorded by acclamation, and

Captain THURSTAN HOLLAND, in reply, thanked the proposer and seconder, and said that he was painfully aware that the subject and possibly the way he had treated it might give rise to some controversy. On one point he must correct Dr. Metcalfe, who had inferred that he was a north countryman. Although connected for so many years with Liverpool, he was really a Somerset man. He thanked those present for the kind way in which they had listened to him.

The proceedings then concluded.

RÖNTGEN SOCIETY.

A General Meeting of the Society was held at the Institution of Electrical Engineers on Tuesday, December 5th, 1916, Capt. Thurstan Holland, M.R.C.S., President, in the Chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society :—

George Vilvandré.

Francis Shillington Scales, M.A., M.D., B.C.

Mortimer Arthur Codd.

Major John Walter Turrel, R.A.M.C. (T.), M.A., M.D.

Charles E. Holland, M.A.

John Drummond Pryde McLatchie, M.B., C.M.

NOMINATIONS.

Herbert Ashley Gaitskell, M.D. (Cantab.), Harrow, Hamlet Court Road, Westcliffe-on-Sea.
Proposed by Geo. H. Rodman.
Seconded by Robert Knox.

Ernest Beresford Keen, L.M.S.S.A., 128, Fulham Road, South Kensington, S.W.
Proposed by Stanley Melville.
Seconded by Robert Knox.

G. W. Rundle, L.R.C.S. & P., 52, Russell Square, W.C.
Proposed by Robert Knox.
Seconded by J. H. Gardiner.

Charles de Silva, M.B., B.S., 52, Elms Road, Clapham Common, S.W.
Proposed by Christopher Kempster.
Seconded by Robert Knox.

The PRESIDENT said that Dr. Rodman had asked him to call attention to the fact that the Royal Photographic Society of Great Britain would shortly be holding its Tenth Print Competition, and he was anxious that the Röntgen Society should be represented thereat. For that purpose, it was necessary that at least four members should send in prints, which need not necessarily be new prints. Dr. Rodman or the Secretary would be very pleased to accept any prints from members, so that the Society might have a representation at the competition. It was desirable to send the prints at once, as the entries would close on December 16th.

Dr. LEONARD A. LEVY then read a paper, "Some Remarks upon Pastilles."

SOME REMARKS UPON PASTILLES.

By LEONARD A. LEVY, M.A. (*Cantab.*), D.Sc. (*Lond.*), F.I.C., F.C.S., *and* HAROLD J. STENNING.

SOME time ago the authors were desirous of producing pastilles of barium platinocyanide for the measurement of dosage. In the course of the preliminary enquiries, their attention was drawn to the great variation in the rate of colour change exhibited by pastilles obtained from various sources. It was therefore thought desirable to investigate as fully as possible the effect of the variation of different factors upon the colour change exhibited by pastilles prepared from barium platinocyanide.

In a communication to the Röntgen Society by one of the authors on the subject of "Fluorescent Screens," it was pointed out that the tetra-hydrate of barium platinocyanide can exist in three different modifications, two of which are crystalline and one amorphous. The table Fig. 1 gives particulars of these forms.

VARIETIES OF THE TETRA-HYDRATE OF BARIUM-PLATINOCYANIDE $BaPt(CN)_4 4H_2O$

PHYSICAL PROPERTIES	CRYSTALLINE A	CRYSTALLINE B.	AMORPHOUS
COLOUR	ORANGE.	APPLE GREEN.	BRICK RED.
CRYSTALLINE FORM.	IDENTICAL.	IDENTICAL.	NONE.
FLUORESCENCE.	VERY FEEBLE.	VERY BRILLIANT	NONE.

Fig. 1.

It is usually supposed that the change in colour of a barium platinocyanide pastille, is due to the dehydration by the loss of two molecules of water of crystallization to the red di-hydrate. This, however, is not the case, the colour change is due to the gradual conversion of the green crystalline to the red amorphous form. This conversion may also be effected by means of mechanical pressure, as, for example, by blows from a hammer; in fact, it is possible to match any tint by varying the number of blows given. The same colour change can also be brought about by heat, but in this case it is a true dehydration effect. It is for this reason that pastilles must not be placed too near to the bulb of the X-Ray tube.

In the course of the investigations, it was found that different preparations of barium platinocyanide, although much the same in appearance to the naked eye, change in colour at very different rates. It was found possible to obtain a very nice adjustment of the rate of colour change by mixing the sensitive and the comparatively insensitive preparations in various proportions. Fig. 2 shows the times required

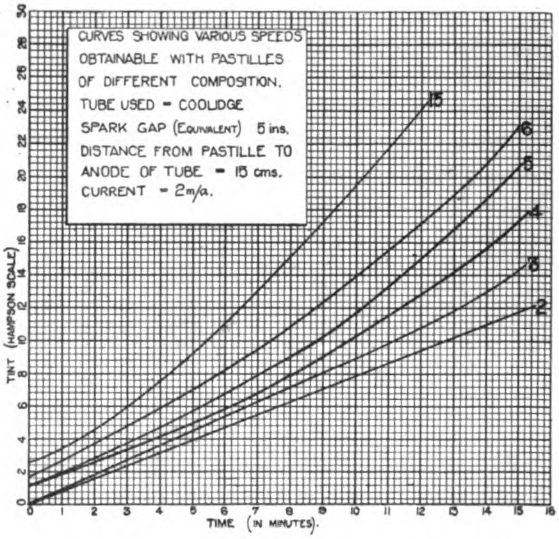


Fig. 2.

by pastilles of different composition to reach various tints on the Hampson scale, the hardness, current and distance being maintained as constant as possible.

Barium platinocyanide prepared specially for fluorescent screens is not very sensitive; this is rather fortunate as screens made from a pastille preparation redden rather quickly and lose considerably in the brilliancy which they display, as the red amorphous modification is non-fluorescent. If pieces of cardboard coated with the same weight of special pastille salt and with fluorescent screen salt are exposed to equal radiation, the difference in the tints assumed is very marked.

One point which is well worth noticing, is that the size of the crystals has a considerable effect on the rate of colour change, and if crystals of two different sizes, but otherwise identical, are exposed to the same radiation for a few minutes, it is seen that the larger crystals assume a considerably deeper tint.

The effect of different factors, such as current strength, hardness, and so forth, on the rate of change of a barium platinocyanide pastille wiil now be considered.

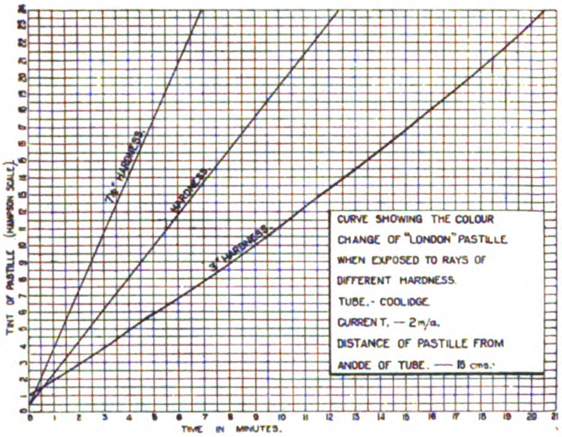


Fig. 3.

Fig. 3 gives the curves showing the relationship between the rate of colour change of the standard pastille and the hardness of the tube. It will be observed that a given tint—say the B tint—is arrived at much more rapidly with a hard tube than with a soft tube, and that the time required for the erythema dose with a certain number of milliamperes depends upon the hardness. This fact is fairly generally known, but is not always realized. It will be noticed that the time is, roughly speaking, inversely proportionate to the hardness. This shows that the pastille gives a true measurement of energy. The current strength and distance of pastille from the anode of the tube were, of course, maintained constant when making these tests.

The curves shown in Fig. 4 are similar to the last, except that the observations were made with specially fast pastilles. These were exposed side by side with standard pastilles made to match the original Saboraud scale. When exposed to soft rays, the fast pastille reaches the "B" tint with the same intensity of radiation in about half the time required by the standard pastille. It will be seen from these curves that

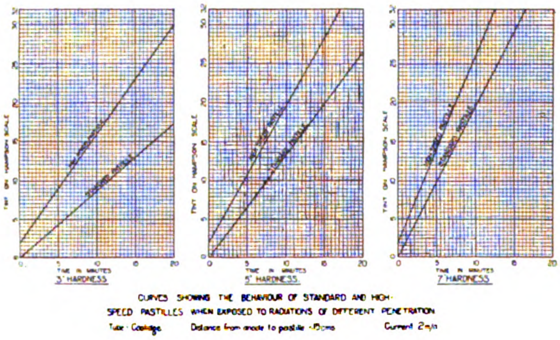


Fig. 4.

the fast pastille also changes colour more rapidly when exposed to harder radiations. The increase in speed, however, is not so great as is the case with the standard pastille.

Fig. 5 illustrates the effect of placing the pastilles at various distances. The time required

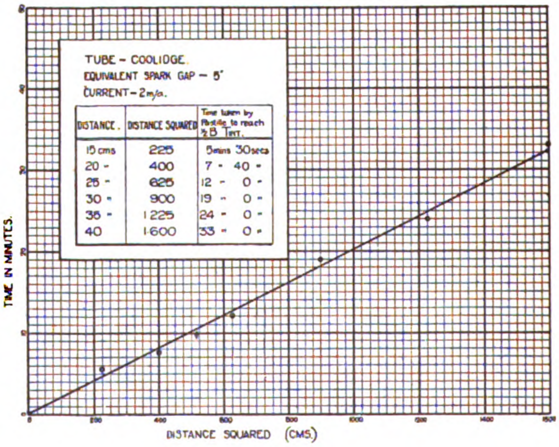


Fig. 5.

to reach a given tint, which was taken as half "B," because the colour change is more rapid there than at "B," is plotted against the square of the distance from the anode of the tube. The result is a straight line, thus showing that the measurement of the pastille is accurate at

different distances. The current strength and hardness of the tube were, of course, kept constant. When using pastilles, therefore, it is only necessary to make sure that the pastille is placed at a distance from the anode equal to half the distance of the anode from the skin of the patient. It is unnecessary, as is sometimes supposed, to keep the pastille at 7½ centimetres and with some tubes this is not practicable.

A number of experiments were made to determine the effect of current strength on the rate of colour change; maintaining the pastille at a fixed distance and keeping the hardness as constant as possible.

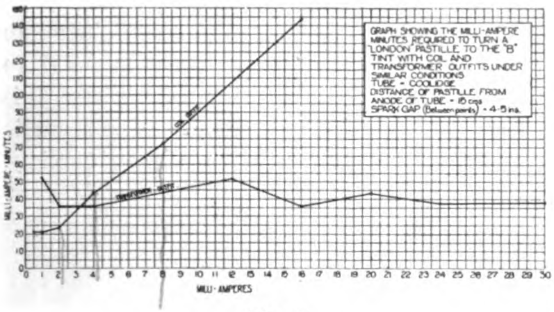


Fig. 6.

The results, see Fig. 6, show that with the coil outfit used, the milliampère-minutes required to turn the pastille to a given colour, increase rapidly when heavy currents are used. This rather corroborates the observations communicated to the Society by Mr. Schall, who made similar tests with a Coolidge Tube on the variation of the time of exposure of photographic plates.

The results obtained with the interrupterless transformer outfit are of quite a different nature. In this case the milliampère-minutes required to turn the pastille to the given tint, allowing for experimental errors, are practically constant for all currents. It also appears that for small currents the interrupterless transformer outfit is by no means as efficient as the coil outfit. The transformer was a 10-kilowatt machine, and the coil used was a 14-in. instrument, operated by means of a mercury radial break.

All the tests hitherto mentioned were carried out with the conventional lead support behind the pastille, but it occurred to the authors that it would be interesting to compare the effect of exposing a number of pastilles exactly similar in composition placed side by side, the one set being supported on a picee of lead and the other

COMPARATIVE TABLES

SHOWING EFFECT OF PLACING PASTILLE ON SHEET OF CARD OR LEAD.

TUBE USED - COOLIDGE DISTANCE FROM PASTILLE TO ANODE - 15cms.

CURRENT - 2m/a. EQUIVALENT SPARK GAP - 5ins.

Pastilles on card.								Pastilles on lead.							
Time	S_1	S_2	2	3	4	5	6	Time	S_1	S_2	2	3	4	5	6
0 mins	2	0	1	0	1	1	2	0 mins	2	0	1	0	1	1	2
5 "	6	4	4	4	5	6	6	5 "	6	4	4	4	6	6	6
10 "	11	7	5	6	8	8	9	10 "	9	8	6	6	9	9	10
15 "	14	12	8	8	13	13	15	15 "	18	12	8	9	15	15	15
20 "	22	20	15	17	19	20	22	20 "	24	19	15	17	21	21	22

Fig. 7.

on a piece of card. The table, Fig. 7, shows the results obtained with seven different pastilles. S_1 and S_2 were Saboraud pastilles obtained from dealers, and the variation in speed already mentioned will be noticed between these two.

Fig. 8 shows the results obtained by some

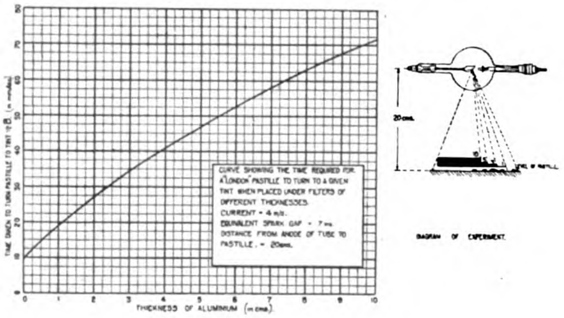


Fig. 8.

experiments made with aluminium filters, using a Coolidge Tube as the source of radiation. The method adopted is indicated in the diagram. It will be observed that the pastilles were exposed to radiation with 0, 1, 3, 5 and 10 millimetres of aluminium respectively interposed between the source of radiation and the pastilles. In

this experiment the aluminium filters were placed close to the pastille, and always at the same distance from the anode of the tube. It will be noticed that the curve is almost a straight line showing that with the particular tube used the increase in the time required to turn the pastilles to a given tint is very nearly directly proportional to the thickness of the filter interposed. It is not considered, however, that a curve of this character will always be obtained, owing to the large variation in the quality of radiations emitted by tubes of different types when working with the same equivalent spark gap and passing the same current.

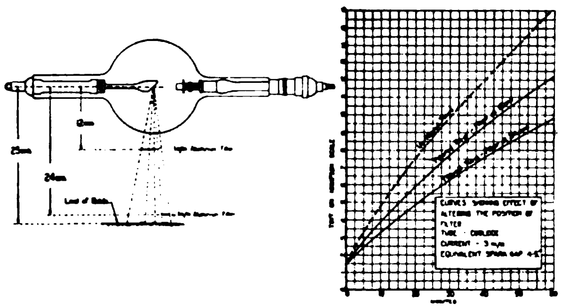
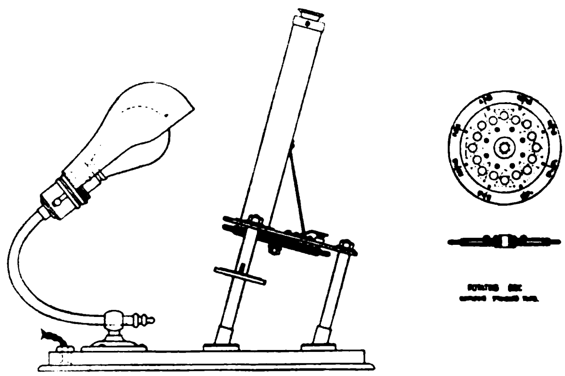


Fig. 9.

Fig. 9 shows the results obtained by some experiments made with two aluminium filters of equal thickness which were interposed between the anode and the pastilles at different distances from the latter. It appears from the results that the filter is more effective in cutting off radiations when close to the pastilles than when further away.

It is, of course, a matter of common knowledge that pastilles after exposure to radiation can be brought back to nearly their original colour by exposing them to daylight. A northern light being preferable to direct sunlight, which may permanently injure the pastille, if very strong. It was found that the revived pastille regains the "B" tint in practically the same time after one or two exposures. Before a pastille is used for a second exposure, it must, however, be carefully examined to see whether it has really come back to its original colour. If it has not done so it can still be used, provided that a proper allowance is made. For example, a pastille which originally read 1 on the Hampson scale, and which was exposed to the rays until it reached tint 16, came back to tint 3 after exposure to daylight for a few hours. It was then exposed to the rays again, being placed side by side with another entirely new pastille from the same batch. It was found that the bleached pastille reached tint 18 in the same time that the new pastille assumed tint 16, the difference of 2 between the initial and final tints being maintained. In the chromo-radiometer, which will next be described, provision is made for this by the insertion of tints $1\frac{1}{8}$ B and $1\frac{2}{8}$B, which can be employed for giving the erythema dose with pastilles which have not completely regained their original colour.

It is well to note that pastilles also tend to regain their original colour when exposed to artificial illuminants, and for this reason it is important that the colour measurement be made as quickly as possible. When using a Coolidge Tube for treatment purposes, the pastille must be shaded from the light of the cathode filament.



LEVY-STENNING CHROMO-RADIOMETER.

Fig. 10.

Finally a short description will be given of a new type of chromo-radiometer for use in conjunction with dosage pastilles. No new principle for this instrument is claimed, but it is maintained that it is a very convenient method for examining pastilles for the estimation of colour change.

The principle of Lovibond's tintometer is undoubtedly the most accurate method possible for comparing and matching colours of every description. This instrument has been applied by Dr. Corbett for the examination of pastilles with very excellent results. The radiometer shown in Fig. 10 embodies the same essential features of colour measurement, in that the reflected light derived from a standard source and transmitted through specially coloured filters is matched against the light reflected from the opaque pastille. In this new instrument the accuracy of the Corbett method has been combined with the convenience of the Hampson Radiometer.

The source of light is an 8-candle-power frosted carbon filament lamp attached in a fixed position to the base of the instrument. The tints are carried in a rotating metal disc, and the viewing tube is so arranged that the pastille is always seen between two consecutive colour tints. This readily enables a very accurate colour estimation to be arrived at. The lower plate is provided with two pegs, on which a piece of matt white paper is fixed, and can be changed when soiled. This serves to reflect the light from the lamp through the colour filters. A ring marked on the paper indicates the correct position for the pastille.

Fig. 11 indicates the method adopted to obtain the tints corresponding to the various doses.

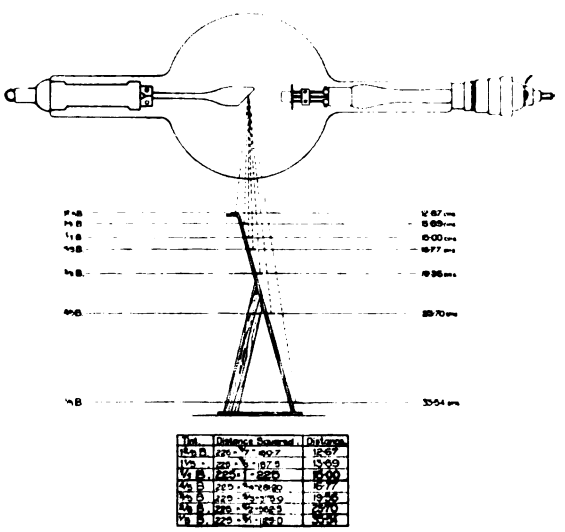


Fig. 11.

The colour change of the pastille, as has already been shown, is inversely proportional to the square of the distance from the anode of the tube, provided that the other factors remain constant. A frame-work was therefore arranged as shown, and the pastilles were placed on projections at distances such that their squares were inversely proportional to the dosages required. By employing this method all the pastilles were exposed to the same beam of rays, and no error was introduced by any slight variation in current strength or hardness. The pastille, placed at 15 cm., was examined from time to time by a number of independent observers, and compared with the Lovibond Standard B Tint.

DISCUSSION.

Mr. B. H. MORPHY said: Amongst many interesting points in the paper the most interesting was the comparison between the results of a coil outfit and a transformer. With the coil the number of milliampère minutes required to produce a certain reaction of a pastille increased very greatly as the current was increased. With the transformer the same number of milliampère minutes were required, whether a small or a large current was passing. I should like to get some adequate explanation of this phenomenon. It would also be very interesting to know whether the same result would be obtained with a coil outfit when using a different type of interrupter. Many people lately have been using the electrolytic interrupter with the Coolidge tube and the coil and have found the combination more satisfactory than the ordinary mercury interrupter.

When considering the matter of efficiency, it should be borne in mind that the actual number of milliampères required to produce a certain effect does not really matter. It is the heating up of the tube which is the only real measure of the loss of energy, and this does not depend solely or even chiefly upon the current. One other point which struck me as particularly interesting is the fact that a filter is so much more effective when further away from the tube than one placed close to it. This is somewhat puzzling at first, but various explanations are feasible.

Dr. G. B. BATTEN: I have worked a great deal with pastilles and for a very long time, and have had a good deal of experience in the treatment of ringworm, and I am always ready to learn new facts with regard to the epilation dose. One question I should like settled is what distance between the surface of the glass of the tube and the pastille may be considered safe. As far as my experience goes, half an inch is sufficient, but although I generally work at this distance, every quarter or eighth of an inch that one can save means a saving of time when doing a large number of cases. With a tube of 7 in. diameter, the distance from the glass to the middle of the anticathode should be 3½ in. But half the diameter of the tube is not necessarily the distance between the focus spot and the glass, for a great many tubes vary in this respect. But we have to work at 8 in. for the full-time distance, and therefore if we can save a little with safety it is an advantage. Even a saving of one-eighth of an inch means a few minutes' difference in the course of an hour's work. I note that all Dr. Levy's experiments have been conducted with a Coolidge tube. The effect from a Coolidge tube through a filter is quite different from that of the ordinary tungsten target tube. There is also the question as to the position of the filter. Practically it is very difficult to put the pastille between the filter and the patient. I should like to see some really convenient way of doing this. Using a tungsten target tube with a spark gap of 6 in., I found that with 3 mm. of aluminium, the relation of a pastille dose on the tube side was as 1 to ¼ on the other side; with 2 mm. it was as 1 to ½, and with 1 mm. it was as 1 to ¾. These seem very nice little figures, but I do not think they are true except for that particular ray, and perhaps for that particular set of experiments. Another thing to be considered is the type of interrupter. I find with a given milliampèrage and a given coil that a slow interruption of the dipper type gives a quicker turn to the pastille than a quicker interrupter. At my own house I was accustomed to use a dipper interrupter, with which a particular tube showed the change in the pastille in seven minutes. Using an alternating current interrupter with a frequency of 50 periods per second, 3,000 per minute, it used to take twelve minutes. Now, by using a tungsten target tube, and running through more milliampèrage, I have got it down to five minutes at the full distance. Another thing on which I should like Dr. Levy to give an opinion concerns the latitude of safety in the epilation or erythema dose as measured by the pastille. If we could be given a really good standard tint it would be a great boon. I have tested the "London" pastille against the others, and certainly, while very good, there are differences. There is a distinct difference of appearance. The Sabouraud pastille has a matt surface, and the "London" pastille a smooth, shiny surface. We want to try and get accustomed to the "London" pastille, and to that end it should be made to approach more closely to the matt surface we have been accustomed to work with hitherto.

Dr. CHRISTOPHER KEMPSTER: I always work with a small tube—13 or 14 cm. in diameter—and I am accustomed to take two pastilles at different distances to use as checks. I place one at 7·5 cm. from the anticathode, and the other at 10·6 cm., which is my skin distance. Naturally, the nearer pastille at 7·5 cm. distance is within ½ cm. or 1 cm. of the glass. I find from experience that when the two pastilles are compared upon Dr. Hampson's radiometer, the nearer is almost invariably double the tint in depth that of the other at the 10·6 cm. distance. Therefore I think we are very safe in placing the pastille at a very close distance to the glass, and, as far as I can tell, the heat generated has very little effect upon the change of the pastille. Dr. Levy said that he hammered his piece of radioactive cardboard. With regard to the other questions raised by the last speaker as to the limit of safety in cases of epilation, that is a point in which I am very much interested. For although one knows that there have been very disastrous experiences in cases of epilation for ringworm where the patient has been over-exposed and the hair has never returned, yet I have been trying to produce a permanent epilation in cases of superfluous hair, but the

hair has invariably returned. I should like to know what is the limit, so that in these cases I could exceed it, and thereby gain my object.

Mr. W. E. SCHALL: I was very much interested in the set of curves shown by Dr. Levy demonstrating the effect of rays, obtained from a Coolidge tube operated from a coil and a high-tension transformer respectively, on pastilles. I showed some results in the course of my paper before the Society last winter, which suggested that apparently the effect on a photographic plate of rays from the Coolidge tube, using the same number of milliampère seconds, and working with a spark coil was different if one used a small number of milliampères for a long time or a large number of milliampères for a short time. In the latter case the effect was less.

I think I may disclose the fact that in the next issue of the Journal there will appear a letter from Dr. Coolidge criticizing these results and saying that they are quite contrary to what has been found by Professor Shearer. The gentleman in question, however, worked with an interrupterless transformer, and it seems to me that Dr. Levy's findings rather go to show that both Prof. Shearer's results and my results, though apparently contrary, are correct. With the coil the effect on the plate of a constant number of milliampère seconds decreases as the current increases. With a transformer on the other hand the effect is constant for all values of the current. An explanation which I ventured to suggest was that for some reason or other, the increase in the milliampèrage obtained from a coil generates such hard radiation that the rays go through the emulsion of the plate without being absorbed, and the same thing may be true of the pastille.

Capt. N. S. FINZI: I congratulate Dr. Levy on the very interesting points he has raised this evening, and also Dr. Batten who has touched upon some other very interesting subjects. With regard to the question of different pastilles, I think it is serious that the pastilles should differ quite to the extent of 30 per cent., and that comparison tints also differ. About seven years ago I got a hundred pastilles, and I had to get no more until quite recently. I was then informed that the Sabouraud tint had been changed, and the new pastilles were quite different from mine. This is rather a matter for our sub-committee on dosage to take up. I should like to ask Dr. Levy a few questions. First of all, I suppose there is no other substance which will give a colour change as marked as barium platinocyanide. Then he mentioned the standard pastille and the special pastille, and showed that the rate of change was different according to the rays used. Which does Dr. Levy consider measures the rays correctly? With regard to the difference in effect with the interrupterless transformer and the coil, I should like to know what sort of break Dr. Levy uses with his coil. It may be that one gets a high peaked curve in the mercury break, and that the extremely hard ray generated does not affect the pastille.

Dr. W. E. HARVEY: With regard to Dr. Levy's diagram having reference to the action of the coil and the transformer, I think it exactly bears out what occurs at the Cancer Hospital in the practice of deep therapy. We get better results with a mercury break and a hard tube, 9-in. spark gap, in regard to time, current penetration and reaction to pastille than we have yet been able to approach so far with the Transformer.

Capt. G. W. C. KAYE: I should like to congratulate Dr. Levy upon his efforts to make the pastille a useful instrument. I think most people who have used it regard it as a very loose kind of thing. The fact that Dr. Levy has gained a measure of success is shown in his confirmation of two well-known facts. The first of these is the inverse square law, the rays obeying the law of the inverse square of the distance like any other radiation. The other point relates to his findings with regard to absorption and scattering in connection with the experiments with the filter. The effect is a well-known one, but one has to look out for it. The difference between the effects with the filter

at the different distances is almost entirely due to scattering. The amount of rays which reach the pastille at a certain incidence is determined by the fact that the rays are not merely absorbed, but are also scattered in all directions by the filter. The effect of scattering is not quite so pronounced at a distance as it is when the rays are close up against the pastille. I should have thought that the change of colour of the pastille would be very pronounced in the case of those rays just hard enough to generate secondary radiation in the material. It is well known in photographic work that the exciting of the characteristic radiations of the silver and bromine present in the plate may greatly affect the result, and the fact that Dr. Levy has got such concordant results in his pastille experiments seems to show that he has been working outside the range of such rays.

Dr. LEVY, in reply, said : I should like, before replying in detail to the various points, to mention that the results we have given you to-night are not at all complete. The experiments are the result of our incomplete investigations, which we had to discontinue owing to the war. We thought it desirable to put forward the results so far as the experiments have proceeded. We hope to take up some of the points, if they still have any interest, after the war is over. One of the matters we fully intended to go into was the question as to whether we got a different curve when using the electrolytic break from that which we got with the mercury break. We are fully of opinion that the results with the electrolytic break are quite different and probably more nearly approach the results obtained with the interrupterless transformer outfit. Dr. Batten raised the question as to how near it is safe to put the pastille to the tube. The only reason why there is need for a definite distance is the heating effect, and the temperature required to convert the green crystals to red crystals is 30 or 35 deg. C. I think that half an inch distance is ample. There is no necessity to go further away. Dr. Batten also mentioned that the results obtained with the filters would probably be different if other tubes were used. We mentioned this point at the time, but we only performed one experiment ; with other tubes different results would be obtained which would depend entirely on the quality of the radiation. Dr. Batten also mentioned that the " London " pastille differed in appearance from the Sabouraud pastille. It would be easy to make a matt surface instead of a shiny one if preferred. With regard to the points raised by Mr. Schall, we had quite intended to mention his very interesting results on the varying exposure of a photographic plate. The results which we have brought forward quite corroborate his and, in fact, are practically of exactly the same nature. With regard to his explanation that the effect may be due to the hard rays going right through the emulsion without being absorbed, would it not be possible to test this by using an intensifying screen ? If an intensifying screen were used in every case, the screen would stop practically the whole of the radiation, even in the case of rays which were quite hard, and if, on using this, the proportion was found to be quite different it would bear out his suggested explanation. If, on the other hand, the proportion was the same, the explanation would have to be sought for in some other dierction. I do not think that this explanation would answer for our pastille results. The barium platinocyanide is a very heavy salt, very effective in absorbing the radiation, and is not analogous to the emulsion of the photographic plate. Captain Finzi raised the point as to the variation of the standard tint supplied. That, of course, is certainly the case, and I can only suppose it is due to the different batches of pastilles having been found to require different standard tints. We have found that it is possible to prepare, as we showed you, a very sensitive modification of barium platinocyanide, and a comparatively insensitive one, and by mixing these in varying proportions, we can adjust the pastille so that it matches the standard. I have not found it possible to prepare various lots of barium platinocyanide to a particular degree of sensibility, but it is always possible to take a very sensitive preparation and an insensitive one, and by mixing them arrive at what is wanted.

I do not see any reason why a standard tint should not be definitely adopted, and pastilles prepared to match this tint only. As to the use of pastilles generally, we hold no brief for them whatever. The whole point is this: we set forth to make pastilles and to try and see if we could produce pastilles four times as fast as the normal one. We also undertook these experiments, the results of which have been given to you, in the hope of making the pastille a little more scientific and exact. If a pastille is used, the light by which it is examined should be specified; to say "daylight" is not sufficient. An artificial standard is better. The hardness of rays also should be specified. It should be stated that it reaches the standard tint with the erythema dose at a certain degree of hardness, and if it is required to use the pastilles at other degrees of hardness a correction should be given. Another point raised by Captain Finzi was the question of the special and the standard pastille, as to which was the more reliable. The standard pastille was one made to match as nearly as possible the Sabouraud scale. There is no difficulty in matching any particular pastille. The question is which is the correct Sabouraud scale. The special pastille, the results of which we also showed you, was one of those made in experiments to form a pastille which turned colour at a much more rapid rate. As we have explained, this special pastille changed in colour rapidly, and it was evident that there would be a definite advantage in obtaining a pastille four times as fast as normal. With regard to the point raised by Captain Kaye as to the concordance of our results, one explanation is that in all the experiments the Coolidge tube was used, and I think that the colour measurements can be relied upon up to within about 5 per cent.

The PRESIDENT: It will be your desire that I should express to Dr. Levy on behalf of the Society the interest we all feel in his paper. It seems to me, if I may sum up the discussion from the point of view of a medical practitioner, that really the less reliance we place upon pastilles the better. We are told, to begin with, that there is a 25 per cent. margin in these pastilles, and in addition to this, Captain Finzi gives us evidence that they vary to such a degree over and above that margin as to make the results very uncertain. Except in the case of ringworm—and there one has to specialize—the pastilles can only be looked upon as an extremely rough guide to the actual dosage at any given time. I personally have come rather to rely on other indications for measuring or estimating the dose I am administering. Another great point which has not been touched upon is the difficulty that the pastilles afford no real comparison of dosage when one is estimating one's own method by the side of that of any other worker. In view of the margin of error in reading pastilles, it is difficult to compare yourself with anyone else in terms of so many pastille doses.

LETTERS TO THE EDITOR.

The British Thomson-Houston Co., Ltd.,
"Mazda House,"
77, Upper Thames Street,
London, E.C.,
November 6th, 1916.

"EXPERIMENTS WITH THE COOLIDGE TUBE."

Dear Sir,—Referring to the paper presented by Mr. W. E. Schall, B.Sc., before the Röntgen Society, and published in the July issue of your journal, copy of this has been forwarded to the inventor of the Coolidge Tube, Dr. W. D. Coolidge, of the Research Laboratories of the General Electric Co., Schenectady, New York (U.S.A.), and I quote from a letter just received from him in comment :—

Yours very truly,
F. W. WILLCOX.

"I was very much pleased to receive a copy of the journal of the Röntgen Society for July.

"Referring to the article on the Coolidge tube: I know nothing about Mr. Schall as an investigator, but if one of the men in our laboratory had brought me his results, I should certainly have asked him to repeat his observa-

tions, taking especial care in the measurement of *voltage.*

" I should also have to point out that plates 3 and 4 prove exactly the opposite of what Schall attempts to prove by plates 1 and 2. (In plates 1 and 2, he shows that, when running under what he thinks are the same conditions, he gets more photographic action from the ordinary gas-filled tube, but plate 3 seems to indicate more action from the Coolidge tube, and plate 4 seems to indicate, at least with the lower milliampèrage, the same action.)

" Plates 1, 2 and 4 seem to indicate that, in the case of the Coolidge Tube, with a given number of milliampère-seconds of exposure, the photographic action is less the greater the current. Plate 3 seems to indicate the reverse of this.

" Most of our own measurements have been made on the transformer, and they are in accordance with those published by Prof. Shearer on page 901 of the December number of the *American Journal of Rontgenology for* 1915. In this publication, Prof. Shearer shows that over a wide range of milliampèrage (from 10 to 100) he gets the same photographic action with the same number of milliampère-seconds of exposure.

" With the use of the induction coil, some difference may come in, but Schall's experimental data on this point do not look very good to me."

The foregoing letter has been handed to Mr. Schall, and he replies as follows :—

71 & 75, New Cavendish Street, W.,
London,
12th December, 1916.

Dear Sir,—I thank you for sending me the letter of the British Thomson-Houston Company in which they communicated the remarks made by Dr. Coolidge about my experiments.

In reply to these remarks, I would say, in the first place, that the equivalent spark gap of each tube was recorded in each experiment. This was the only check on the secondary voltage which I had at my disposal at the time. I think, however, that as a rough guide to the secondary voltage this method serves sufficiently well.

The second point which is raised is, I fear, accounted for by the reproduction of the photographs.* The original negative No. 3 clearly shows strip 2 slightly lighter than strip 1 and strip 4 distinctly lighter than strip 3.

The original negative of No. 4 shows strip 4 considerably lighter than strip 3, but strip 3 darker than strip 2. Now, I recollect mentioning during the reading of the paper (though it has not been recorded in print) that the case of different action on photographic plates as between Coolidge and ordinary tube had not been made out, but that, on the other hand, the more important point of different photographic action of the Coolidge tube rays at the same milliampère second value, but with different currents had been made out conclusively.

The same result has recently been arrived at independently. At the last Röntgen Society meeting, Dr. Levy showed that a Coolidge Tube operated by a high-tension transformer shows the same effect on pastilles for varying currents with a constant milliampère second value, but that the same tube worked by a coil produces a smaller effect with high currents than with low ones, though the milliampere second value remains constant. Thus both the results of Prof. Shearer, which are quoted by Dr. Coolidge, and my own have been confirmed.

The point still awaits explanation, and I can only assume that it is again a result of the difference in form of current wave obtained respectively from a Coil and from an interrupterless Transformer.

I am, Dear Sir,
Yours faithfully,
W. E. SCHALL, B.Sc.

*There is very considerable difficulty in reproducing the faint gradations in tone accurately by the half-tone process, the blocks were made twice and finally passed by the author as probably the best that could be done.—(EDITOR).

NOTES.

THE CONDENSATION PUMP: AN IMPROVED FORM OF HIGH VACUUM PUMP.

By IRVING LANGMUIR, Research Laboratory, General Electric Company, Schenectady, N.Y.

THE *General Electric Review* for December, 1916, contains an interesting and important article upon the construction of these pumps by Irving Langmuir. After describing the principle and construction of the first form a further improved glass pump is described and illustrated. This piece of apparatus is so simple and ingenious that the description is reproduced in full below. The theory of the action and many other details connected with the research are given at great length, and finally a "Condensation" pump built entirely of metal is described.

THE IMPROVED TYPE OF GLASS PUMP.

To completely avoid these difficulties the design shown in Fig. 3 was adopted. In this pump, mercury vapour from the flask *A* is carried through the thermally insulated tube *B* to the nozzle *L*. The vessel to be exhausted is connected to *R*. The gas from this vessel passes through the trap *G* and the tube *F* into the annular space *E*. At *P* this gas comes into contact with the mercury vapour blast issuing from the nozzle *L*

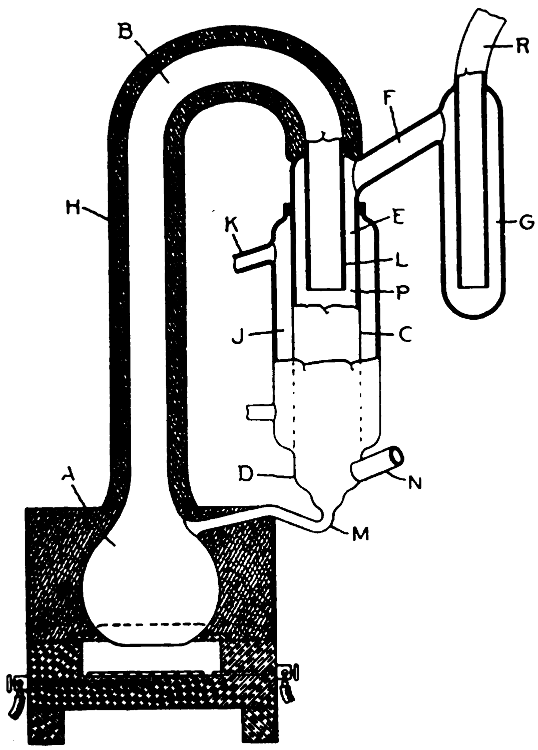


Fig. 3

and is thus forced *outward* and *downward* against the walls of the tube *C* and is finally driven down into the space *D* from which it escapes into the rough pump connection *N*. The mercury which condenses on the sides of the water-cooled tube *C* passes back through the tube *M* into the boiler *A*.

By this construction none of the mercury which condenses passes into the annular space *E* and thus the troublesome blast of mercury into the tube *F* is wholly avoided. The glass-blowing work on this type of pump is also much less difficult than on the earlier type.

In the newer pump (Fig. 3), the enlargement of the tube *C* and the second condensing chamber are eliminated entirely. This greatly simplifies the construction without materially affecting the operation of the pump. It is true that the speed of operation appears to be somewhat higher in the type containing the enlargement, but the speed of these pumps is usually so excessive even without the enlargement that a further increase in speed serves no useful purpose.

In order that the pump may function properly it is essential that the end of the nozzle *L* (Fig. 3) shall be located below the level at which the water stands in the condenser *J*. In other words, the overflow tube *K* must be placed at a somewhat higher level than the lower end of the nozzle as is indicated in the figure. The other dimensions of the pump are of relative unimportance. The distance between *L* and *D* must be sufficiently great so that no perceptible quantity of gas can diffuse back against the blast of mercury vapour, and so that a large enough condensing area is furnished.

The pump may be made in any suitable size. Some have been constructed in which the tube *B* and the nozzle *L* were one and a quarter inches in diameter while in other pumps this tube was only one-quarter of an inch in diameter and the length of the whole pump was only about four inches. The larger the pump the greater is the speed of exhaustion that may be obtained.

ACTION OF LIGHT ON IODINE AND STARCH IODIDE IN AQUEOUS MEDIUM.

H. BORDIER (*Comptes Rendus*, 1916, 163, 205-206).

DILUTE solutions of iodine with starch paste are discoloured by exposure to sunlight in a few hours, but not if kept in the dark; a trace of iodine will restore the colour; light passed through yellow glass also causes the discoloration. The same effect is produced by X-rays only very much more quickly, a few minutes, in contrast to hours by ultra-violet light.—(*Comptes Rendus*, 1916, 163, 291-293.)

THE SKIAFIX.

A DEVICE placed upon the market by Messrs. Siemens Brothers & Co., Ltd., of Caxton House, Westminster, London, S.W.

This appliance should be of value at the present time in cases where radiographing is required and the patient has no power to control movements. When suitably clamped the Skiafix enables any limb to be kept perfectly steady and free from involuntary movement. Moreover, limbs which cannot be rotated by voluntary action on the part of the patient can be rotated by means of the clamps holding the extremities. The apparatus also enables radiographs to be taken in two directions without moving the limbs; and many cases which cannot be removed from stretchers can be radiographed without removal with the utmost ease.

X-RAY PLATES.

Next to the X-ray tube the photographic plate is perhaps the most important adjunct in the practice of radiography. Its perparation and manufacture is of supreme importance at the present time.

Messrs. Elliott & Sons, the manufacturers of the "Barnet" X-ray plate, have devoted considerable at tention to this subject with no small success. The "Barnet" plate is used in very many important hospitals and institutions.

It is gratifying to know that this is an instance of successful home manufacture, a circumstance which should influence those who are responsible for the supply of plates for our hospitals, ships and camps.

ABSTRACTS.

The following are selected from the current numbers of "Science Abstracts" as likely to be of special interest to members of the Society, and are published by permission of the Editors of that Journal.

1129. *X-ray Spectra of the Elements Na to Cr.* M. Siegbahn and W. Stenström. (Phys. Zeits. 17, pp. 318-319, July 15, 1916.)—In an earlier paper [Abs. 680 (1916)] a description was given of a determination of the X-ray spectra (K series) of the elements Ce and Cr. With the latter element the absorption in the X-ray tube and in air becomes serious, and modifications in the previous method become essential. The results of the research are included in the subjoined table.

	$\lambda \times 10^8$ cm.					
Element.	α_2.	α_1.	α_3.	α_4.	β_1.	β_2.
26 Fe	1·932	1·928			1·748	1·376
25 Mn	2·097	2·093			1·902	1·892
24 Cr	2·288	2·284			2·079	2·069
23 Va	2·502	2·498			2·281	
22 Ti	2·746	2·742	2·729		2·509	2·492
21 Se	3·032	3·028	3·011		2·778	
20 Ca	3·359	3·355	3·328		3·086	3·074
19 K	3·738	3·735	3·724		3·449	
18 Ar						
17 Cl	4·712		4·692		4·394	
16 S	5·360		5·317	5·314	5·018	(5·029)
15 P	6·168		6·129	6·122	5·808	(5·853)
14 Si	7·131		7·088	7·080	6·759	
13 Al	8·360		8·310	8·300	7·986	
12 Mg	9·915		9·856	9·845	9·477	
11 Na	11·951					

A. B. W.

1276. *Action of Calcium in a Discharge Tube.* H. B. C. Allison. (Phys. Rev. 7, p. 688, June, 1916. Abstract of paper read before Am. Phys. Soc., April, 1916.)—A Plücker tube of the usual type about 8 in. in length, and having a capillary connecting the two electrode chambers, is used. The electrodes are All rods mounted on Pt-wires. In one of the electrode chambers some calcium chips are placed before the electrode is scaled into the tube. The usual lamp exhaust is given, and the tube filled with argon of at least 99·8 per cent. purity. After washing out the tube twice is it sealed off at 2 mm. pressure and connected with a high-voltage transformer. A spectroscope having been put in position, the spectrum is observed to be a combination of argon lines and nitrogen bands, with four prominent hydrogen lines. As the tube continues to run the nitrogen disappears first and then the hydrogen, until only the pure argon spectrum remains. During this time the calcium chips are in the path of the discharge, but not in contact with the electrode. The tube is then inverted, and shortly afterwards the hydrogen lines appear as brillinatly as at first. The calcium is then in contact with the electrode. Upon returning to the original position the clean-up of of the hydrogen again takes place. It is possible to repeat this reversal a large number of times, but so long as any calcium remains in contact with the electrode, hydrogen is always present in the spectrum. This is undoubtedly due to the formation of calcium hydride in the first position, and its subsequent decomposition when in contact with the electrode. A. E. G.

1294. *Radiologic Dosimetry: Theoretic and Experimental Researches.* R. Ledoux-Lebard and A. Dauvillier. (Comptes Rendus, 163, pp. 171-174, Aug. 14, 1916.)—The method of exciting Röntgen tubes previously described [Abs. 726 (1916)] has the disadvantage that the homogeneous kathode rays produced give rise to a heterogeneous radiation, so that the analysis of the radiation is always difficult and the precise dose not easy to determine. It is now proposed to make use of special tubes which produce a monochromatic radiation or, at least, a spectrum composed of only a very small number of rays. A diagram of a tube based upon principles which are enunciated is shown and briefly described. As it appears probable that Röntgen rays of different wave-lengths do not possess identical therapeutic properties a series of tubes of this class would make it possible, in each clinical case, to choose the most efficacious radiation. Since continuous current is used the working conditions are definite, and so the radiologist can rely upon always obtaining an identical radiation. So far as the dose is concerned the only measures required to be made are the intensity and the time. A. E. G.

1250. *Density of Radio-lead from Norwegian Cleveite.* T. W. Richards and C. Wadsworth. (Am. Chem. Soc., J. 38, pp. 1658-1660, Sept., 1916.)—A brief description is given of the determination of the density of lead from a particularly pure specimen of Norwegian cleveite. The lead separated out from the mineral, and presumably a pure isotope, was found to have a density 11·273, decidedly lower than that from a sample of Australian radio-lead previously studied (11·289), and still lower than the density 11·337 found for ordinary lead. The corresponding atomic volume of the pure isotope is essentially equal to that of ordinary lead, as indicated by earlier results on Australian radio-lead. A. B. W.

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RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Institution of Electrical Engineers on Tuesday, January 2nd, 1917, Captain C. Thurstan Holland, M.R.C.S., President, in the chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society:—Miss ANNE IRENE ANDERSON, H. A. GAITSKELL, M.D., E. B. KEEN, L.M.S.S.A., G. W. RUNDLE, L.R.C.S. and P., C. de SILVA, M.B., B.S.

NOMINATIONS.

EDMUND EDWARD FOURNIER D'ALBE, D.Sc., Physicist, Binbrook, East Moseley, Surrey.

Proposed by SIDNEY RUSS.
Seconded by CECIL R. C. LYSTER.

WILLIAM NEAVE KINGSBURY, M.R.C.S., L.R.C.P., Assistant Electro-Therapeutic Department. Middlesex Hospital, W.

Proposed by CECIL R. C. LYSTER.
Seconded by SIDNEY RUSS.

DAVID MORROW, M.R.C.S., L.R.C.P. (Lond.), Assistant Electro-Therapeutic Department, Middlesex Hospital, "Woodhurst," Old Park Road, Palmers Green, N.

Proposed by CECIL R. C. LYSTER.
Seconded by SIDNEY RUSS.

Mr. C. A. SCHUNCK read the following paper:—

A SPECTROSCOPIC INVESTIGATION OF SOME SOURCES OF ULTRA-VIOLET RADIATION IN RELATION TO TREATMENT BY ULTRA-VIOLET RAYS.

By CHARLES A. SCHUNCK, F.C.S.

As ultra-violet radiation is extensively used therapeutically, I thought that a spectroscopic comparison of some of its sources showing their constituent radiations, wave-lengths and relative intensities and the attempt to ascertain the most efficient for the purpose would be of interest and value.

THE REGIONS OF THE SPECTRUM.

The visible region of the spectrum extends from about λ 7594 Angström units (the unit is $\frac{1}{10^{10}}$ metre) in the extreme red indicated by the A group of atmospheric lines in the solar spectrum to the two broad lines H and K due to calcium in the violet, the wave-length of the latter being λ 3934. The ultra-violet region in which we are interested extends from here and can be recorded on the photograph plate using quartz lenses and prism (ordinary glass very soon begins to absorb these rays) to λ 2930 in the solar spectrum, when atmospheric absorption, the principal factor being ozone, takes place for radiations of shorter wave-length. By using the spark or arc discharge with metal electrodes, etc., or quartz vacuum tubes the spectrum is extended to λ 1850 where an abrupt termination of the spectrum takes place, due, as Schumann ascertained, to absorption by the oxygen of the atmosphere. Within these limits λ 3934 and λ 1850 is understood as the Ultra-Violet Region and this is the effective extent of the radiations

therapeutically through the strong atmospheric absorption at the lower limit.

The ordinary photographic plate will only record to about λ 2150 as the gelatine of the emulsion now begins to absorb the radiations strongly and to obtain a photographic record to λ 1850 the Schumann plate, which contains a minimum of gelatine in the emulsion, should be used. The ultra-violet spectrum extends considerably further than λ 1850. Schumann, to whom is due the extension of the spectrum, substituted fluorite for quartz, as the latter transmits but a small percentage of the radiations at λ 1850 and soon ceases to transmit, and adopted a vacuum spectroscope. By this means he recorded λ 1230 but he got no further as fluorite absorbs the radiations of shorter wave-lengths. This is known as the Schumann Region. Lyman later in 1914, using a concave grating, which dispenses with the necessity of lenses, enclosed in a brass tube 11 c.m. in diameter and over a metre long containing hydrogen at a pressure of 2 to 3 mm., and using a strong disruptive discharge through a discharge tube, was able to extend the spectrum to λ 900 and in 1915 by substituting He free from N for H and giving an exposure of about 10 m., repeatedly observed a number of new lines, the most refrangible of which was λ 600. From here to about λ 8, where the softest characteristic X-rays of A1 have been recorded, is an unexplored region, the region where that profound change from Light radiation to X Ray takes place and which, when means are devised for its investigation, may lead to most important results. Lyman considers it can be still further extended below λ 600 by purely spectroscopic means.*

The following table gives the Spectrum Regions :—

Visible Region ...	λ 7594-3934	A.U.
Ultra-Violet Region	λ 3934-1850	,,
Schumann ,,	λ 1850-1230	,,
Lyman ,,	λ 1230-600	,,
Unexplored ,,	λ 600-8	,,
X & Gamma Ray,,	λ 8-·07	,,

* The Extension of the Spectrum beyond the Schumann Region: Theodore Lyman, *Astrophysical Journal*, March, 1916.

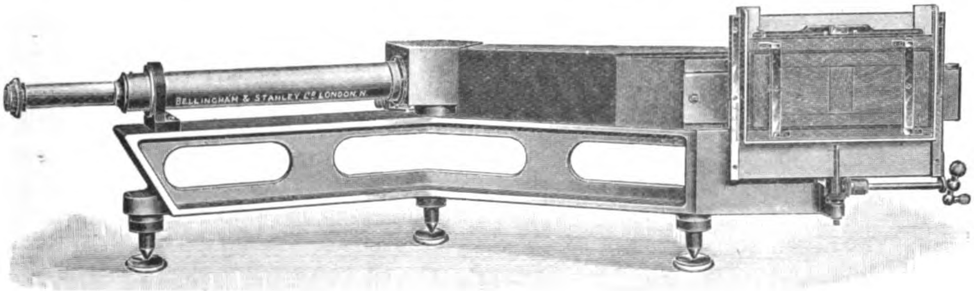
The wave-length of the soft X. Rays is of the order of 1 Angström unit and of the harder ·25. The value ·07 is for the most penetrating rays from Radium C given me by Sir Ernest Rutherford, F.R.S., in 1915, who also gave his measurement of the hardest rays from the Coolidge tube as ·14 A.U.

THE QUARTZ-SPECTROGRAPH.

The Quartz Spectrograph with which the spectra were recorded is of well-known design and admirably adapted for the purpose. The one here depicted was completed for me last year by Messrs. Bellingham & Stanley, London, and has various improvements upon the original model of A. Hilger & Co., from whom I had one of the first in 1908. The salient features are its compactness, the complete enclosement of the prism and lenses, being able to take the entire spectrum from the extreme red to the ultra-violet at λ 2100 on one plate 10″ long in excellent focus throughout, and that when once set no further adjustment is required. There is one quartz prism of the Cornu type. The Collimator lens has a focus of 21″ and to the centre of the plate from the Camera lens is 24″. The overall dimension is 4½ ft. and the base being of aluminium one person can lift it and move it about easily.

The dark slides take 10 × 2 and 10 × 4 plates and fit into a metal holder that is moved mechanically, so that one spectrum can be taken under the other, the width of the spectrum being regulated by the wedge of the slit which is calibrated There being no play between the metal holder and the part it works in one spectrum is accurately comparable with another on the plate. The system being quartz, the plate holder has to be given a considerable tilt, in this case 23° to the Camera axis. The Camera lens has a focussing screw to give the final adjustment. The most important adjunct is the wave-length scale which is calibrated for the instrument, reading to 50 A.U. between λ 6000 and λ 5000, 25 A.U. between λ 5000 and λ 3500, and 10 A.U. from λ 3500 to λ 2100, and as in the prismatic system the spectrum is more extended towards the shorter wave-lengths the

further we proceed, greater accuracy and dispersion is obtainable at the lower wavelengths. The scale can be thrown in at will and photographed above the spectra in exact juxtaposition by illuminating it with a small electric bulb, a second or two being sufficient. The pitch of the slit screw is $\frac{1}{50}''$ and the drum head of the slit adjustment has 100 divisions, therefore at division 1, the slit jaws are $\frac{1}{5000}''$ apart and all the spectra were taken at division 3, which is the narrowest practically to work at for this slit. A quartz cylindrical condenser was placed 16″ from the slit and the arc, 3¼″ in front of the condenser, was brought thereby to a focus on the slit as a band ½″ wide, and in the case of the spark ¼″ wide.



For the arc spectra the voltage was 100 and the ampèrage was varied from 5 to 10. For each plate the ampèrage and exposure for each spectrum thereon was kept constant so as to get comparable results. The exposures in the arc spectra varied from 5 to 15 sec., whereas the corresponding spark spectra took 2½ to 5 m. The plates used were Wratten & Wainwright Pan-chromatic and the sources were compared on the same plate. The various sources were examined both in the arc and spark discharge, though the latter is hardly applicable therapeutically in general, the spark only being a point of light compared to the arc and to be at all practicable would have to be condensed and then but a very small area would be covered. This might be useful in some cases, however.

THE SOURCES OF RADIATION.

The sources of radiation examined consisted of metallic electrodes of pure* W. Mo and Fe, ¼″ carbon rods impregnated by boiling in solutions of Sodium Tungstate, Uranium Nitrate, Ammonium Molybdate, and Titanous Chloride and ½″ cored carbons filled with U_3O_8, Fe_2O_3, Wolfram (a Tungstate of Iron and Manganese) the principal ore of Tungsten, and pure W and Mo (99 per cent.) in the form of powder together with the Simpson electrodes which are said to consist of Wolfram. These, as you are aware, are very unsteady in the arc, splutter badly, and a glassy deposit forms on the electrodes that has to be removed before the current will pass again, whereas the above carbons are are quite steady, which is a great advantage.

The reason for trying the impregnated and cored carbons is the readiness one can assimilate any substance for the arc discharge and the endeavour to get, if possible, a more intense and cheaper source in this manner than the Simpson's or metallic Tungsten. From the spark spectra experiments I had high hopes that the carbons impregnated with Uranium Nitrate and Ammonium Molybdate, known as the "Jones electrodes" and used as a source of light for recording absorption spectra in the ultra-violet, as the lines are so numerous and close together as to form almost a continuous spectrum, would prove an excellent source and rival that of W, whose spectrum is of similar character. But though it has a more intense spectrum than W in the spark and of greater extent it falls off considerably after λ 2500 and ends at λ 2300 compared to W in the arc, which

* W = Tungsten, Mo = Molybdenum, Fe = Iron, Ti = Titanium, U = Uranium, Mn = Manganese, C = Carbon.

extends to λ 2200 on this plate. W also appears to be more intense in the arc than the spark (Plate 3, Figs. A. and B).

THE SPECTROSCOPIC RESULTS.

The following are the spectroscopic results obtained :—The most intense and richest source of ultra-violet radiations is that of the W metallic electrodes in the arc. The spectrum, as is well known and was shown to you at a meeting last year by Messrs. Morphy & Mullord in their paper on "The Enclosed Tungsten Arc," and also by Major Wilson, C.A.M.C., when describing a new Tungsten Arc Lamp he has devised, consists of very many lines of nearly equal intensity throughout the Ultra-Violet Spectrum, so close together as to form an almost continuous spectrum extending with but slight loss of intensity to λ 2130 (the limit of the instrument). The W spectrum and the Simpson electrodes extends further with the same ampèrage and exposure than any of the sources examined. The Mo arc spectrum is of a similar character, but not so intense throughout, extending to x 2190 but losing in intensity at λ 2300. The Fe arc spectrum is very rich in Ultra-Violet radiations and though containing some very intense groups of lines is not so uniform throughout as that of W and extending only to λ 2250 (Plate 3, Fig. C). Its spark spectrum is characterized by a maximum of intensity in the neighbourhood of λ 2400, which maximum is not so pronounced in the arc (Plate 3, Fig. A). The spectrum of the Simpson electrodes is very similar in character and of the same intensity as that of the W arc, but their unsteadiness may detract from their effectiveness therapeutically as compared to metallic W electrodes with the same treatment exposure. Dr. Sydney Russ was the first to examine the spectrum and to compare it with that of pure W. He pointed out and came to the conclusion that they were apparently identical, thus rendering a signal service. The Wolfram cored carbons have a similar spectrum, but are not so intense with the same ampèrage and exposure. A careful comparison of the spectra of W, Simpson's and Wolfram, shows that though very similar, supporting Dr. Russ's conclusion, yet there are differences from the W spectrum, and giving an increased ampèrage to the Wolfram carbons almost an exact match is obtained between the Simpsons and them (Plate 3, Fig. D).

Of the cored carbons the W powder gives a less intense spectrum than the W electrodes. Fe_2O_3 almost equal to the Fe electrodes with advantage of steadiness which the latter lack as they scintillate considerably. Mo powder, like the Mo electrodes, consisting of many lines extending to λ 2300, but not nearly so intense. The U_3O_8 was disappointing and better results were to be expected. The oxide, however, was not reduced to the metallic state by the arc discharge, which may be the cause, and shortly I hope to be able to examine the arc spectrum of metallic Uranium as electrodes. The spectrum loses intensity at λ 2600 but so far the lines are much closer together than W and the spectrum more intense. The numberless lines and their closeness both in the arc and spark spectrum of U are its great characteristic (Plate 4, Fig. G).

The impregnated carbons in the spark are much more intense than in the arc. The Uranium Nitrate and Ammonium Molybdate impregnation gives a magnificent intense almost continuous spectrum extending to λ 2300 without much loss of intensity and is the most intense and richest in ultra-violet radiations of any spark source. The carbons impregnated with Sodium Tungstate are not nearly so continuous or intense (Plate 4, Fig. E). In the arc as far as λ 2500 the carbons impregnated with Uranium Nitrate and Ammonium Molybdate are more intense and continuons than the W arc, but their spectra do not extend as far, λ 2300 being about the limit. The Sodium Tungstate and Titanous Chloride impregnation are particularly poor (Plate 4, Fig. F). The same impregnated carbons were used both for the spark and arc spectra.

RADIATIONS OF THE SOURCES USED IN TREATMENT.

By comparing the arc spectra of carbon, the

iron spark and arc, the mercury vapour arc, the Simpson electrodes and metallic Tungsten in the arc, the nature of the radiations and the intensity of the various sources that have been and are used in ultra-violet radiation treatment is seen (Plate 5, Fig. H). Carbon is the source used in the Finsen lamp, the spectrum being very poor in ultra-violet rays and the exposure as long as 70 minutes at a time. After the Finsen lamp, I believe both the iron arc and spark were used, the latter with a quartz condenser with exposures of three minutes; then the Mercury vapour arc as in the Kronmyer lamp with a quartz-condenser as a compressor on the skin, with exposures of three minutes or thereabouts. This spectrum consists of intense isolated bands and lines, the most intense and broad of all being just inside the Schumann Region at λ 1849·6. A year ago the Simpson electrodes were the vogue until Major Turrell adopted metallic Tungsten, with which the maximum exposure is five minutes, and which has now become of general use.

In regard to filament lamps, like the spectrum of all incandescent solids, the spectrum which is a continuous one falls short of λ 3000, so they are hardly suitable for ultra-violet radiation treatment where radiations of shorter wave-length are the effective ones therapeutically, as I believe I have been able to prove.

THERAPEUTICAL EXPERIMENTS.

Through the valuable advice and assistance of Major Turrell, R.A.M.C., Electro-Therapeutic Physician to the Radcliffe Infirmary, Oxford, to whom I am much indebted for the therapeutical aspect of ultra-violet radiation, I have been able to make some simple therapeutical experiments of the more intense sources.

In a paper* read before the Section of Electro-Therapeutics of the Royal Society of Medicine last year, Major Turrell finds that the W arc (he was the first to apply this source) is the most efficient source clinically of ultra-violet radiation and superior in results obtained from the Simpson electrodes, which is supported by the spectroscopic examination. Within certain limits, he states, the intensity of the erythema produced on the skin in a given time may be taken as measuring the clinical efficiency of the radiation of the source. The open W arc he places one foot from the part to be treated, giving an exposure of five minutes with an ampèrage of 5 to 10, voltage 100, as the maximum dose.

In conjunction with him my fore-arm was exposed for five minutes at a distance of 12″, with a current strength of 5 ampères over different areas of the skin, to the action of the electrodes in the arc of metallic W, Simpson's and half-inch cored-carbons filled with U_3O_8 W powder, Wulfram and Fe_2O_3. The cored-carbons, which burned very steadily, gave no erythema. The W a fair reaction and the Simpsons slight in twelve hours, the former gave a slight redness in two hours, the latter very slight in the same time. To get an increased effect I used the quartz cylindrical condenser under the same conditions as the spectra were taken, which forms an image of the arc 16″ from the condenser in the form of a band about ½″ wide on the skin of the fore-arm, the arc source being 3¼″ from the condenser. The current strength, voltage 100, was 9 to 10 ampères and the exposures about two minutes. An intense erythema was produced in a few hours with metallic W (indication in ½ hour) not quite as much with the Simpson's (indication in one hour) and fairly intense with metallic Fe electrodes and the carbons cored with Wulfram (indication in two hours). The exposure in this case was 2½ minutes, ampères 10. Using W as one electrode and a soft cored carbon the other, alternately as positive and negative, compared to W as both electrodes there appeared but little difference in the erythema produced. With W as the positive electrode the arc is much the steadiest and very steady indeed. The three spectra at at 9 ampères and 10 seconds exposure showed very little difference in intensity, W the best then W as the positive electrode. Carbons impregnated with Uranium Nitrate and Ammo-

* "Ultra-Violet Radiation from the Tungsten Arc." 20th Oct., 1916.

nium Molybdate, 9 ampères and four minutes' exposures gave a faintish erythema in twenty-four hours and no reaction with two minutes' exposure. One mm. thickness of glass in front of the condenser with an exposure of four minutes at 9 ampères gave no reaction to the W arc, neither was there a reaction with a piece of microscopic cover glass in front, whereas the W arc with two minutes' exposure gave a good redness on the skin in twelve hours. These cover-glass experiments were repeated several times, and there was no difference if the glass was placed on the skin. Only in one experiment was there a slight reaction with 2½ minutes' exposure and 10 ampères and in this experiment I am not certain whether the glass was covering the lens completely. The 1 mm. glass and the cover glass, tested spectroscopically under the same conditions as the erythema experiments were made, cut oft the spectrum at λ 2950 and λ 2750 approximately. This shows, I think, fairly conclusively that radiations of λ 2750 approximately and upwards have no therapeutical value as judged by the erythema effect, whereas if the one experiment is correct there is an effect between λ 2750 and λ 2950. It must be remembered these experiments were only made upon my own skin ; still an exposure of 4 minutes to the W arc with the condensing lens is a very severe test, seeing that in the arc experiment of 2½ minutes at 10 ampères, the erythema was so intense that it persisted for three weeks, the skin disquamating and causing a fair amount of irritation. Dr. Sydney Russ in a paper* to the *British Medical Journal* last year states that "the skin is very absorbent to ultra-violet radiations—a piece of skin from the human abdomen $\frac{1}{10}$ mm. thick placed in front of the slit of the spectrograph with the Simpson arc 20 c.m. distant, and giving an exposure of 2 minutes, cuts off the spectrum approximately at λ 3000, shows that ultra-violet radiations between λ 3000 and λ 2100 are very easily absorbed by the human skin," and this is the *same* region I find of therapeutical value. "With thickness of ½ mm. and 1½ mm. of skin and an increased exposure of 8 minutes, the radiations between λ 3000 and λ 3800 were transmitted, but he considers it is doubtful whether more than 1 per cent. of the radiation penetrates as deep as 1 mm." These two sets of experiments tend to show that the therapeutical effect is limited to the superficial tissues and this is also the opinion of Major Turrell from the clinical aspect, who states in the paper above mentioned that "the therapeutical value of ultra-violet radiation appears to be due to its destructive action on micro-organisms and to the active hyperæmia which it induces in the superficial tissues."

I have also proved while constantly working with the W arc in this research, that a sheet of 1 to 1½ mm. glass placed between the arc and the face is a perfect protection from the effects of the radiations, especially to the eyes, which are particularly sensitive, which is supported by my own experience, my eyes being much affected before adopting this means of protection. During one day's experiments I calculated I was subjected for half an hour to the W arc one foot away, and with this simple protection there was no effect on the eyes or skin.

I think one can safely assert that the radiations of greatest therapeutic value lie between λ 3000 and λ 1850, and I am now endeavouring by spectroscopic means to ascertain which part of this region has the greatest therapeutic efficiency. The W arc is the most intense source of radiation there is at present for the purpose. The open arc can be increased in intensity by using a quartz condensing lens, the absorption of which for these radiations is but slight. Pflüger for a piece 1 cm. thickness gives the value of 5·8 per cent. at 2200, 8 per cent. at λ 2140, 16·4 per cent. at λ 2030, but as much as 32·8 per cent. at λ 1860. While Collentz finds that throughout the spectrum to λ 2500 it is almost perfectly transparent in thicknesses up to 3 cm. If a reflecting mirror is used,* then Platinum and Nickel will be found superior to Silver and

* "From the visible to the Gamma Ray spectrum." Jan. 22nd, 1916.

* "The Reflecting Power of Metals in the ultra-violet region of the spectrum," by E. O. Hulbert, *Astrophysical Journal*, vol. 42, p. 205, 1915.

Silicon, the best of all reflecting surfaces. Silver reflects on an average 30 per cent. of the radiations between λ 3000 and λ 2000, Platinum and Nickel about 45 per cent., but Silicon as much as 76 per cent. for an angle of incidence of 18°. Mirrors of these substances can be readily prepared by Cathode spluttering or electro-plating.

I have to thank Dr. Oberlander, Ph.D., Mr. J. C. Gardiner, F.C.S., and Mr. Arthur Schiff for the pure substances experimented with, and I am much indebted to Professor W. H. Perkin, F.R.S., for so kindly giving me the facilities of carrying on part of this investigation at the New Chemical Laboratories at Oxford.*

DISCUSSION.

Major W. J. TURRELL referred to the value of Mr. Schunck's spectroscopic work both from the physical and clinical point of view; he drew attention to the very great difficulty at the the present time in obtaining metallic Tungsten.

While admitting that treatment by Ultra violet light offered a field of very great possibilities in electro-therapeutics he warned workers against excessive enthusiasm on the one hand and scepticism on the other, in both eczema and the treatment of wounds it had been found extremely useful; it produces an active hyperæmia which lasts for a considerable time.

He thought that two kinds of lamps were needed for therapeutic purposes, open, with a director or condenser taking ten to twelve amperès, and a smaller one enclosed, taking about half that current, to be worked off the usual lighting circuit for the treatment of septic superficial wounds—such a lamp would find a wide sphere of usefulness in the treatment of wounded soldiers.

Major ROBERT WILSON congratulated the author upon the usefulness of his paper, but thought that a lamp with a positive pole of tungsten and a negative of cored carbon proved a useful combination. It was possible to obtain a good erythema in about three minutes; such a lamp he showed and described at the meeting of the Society in May, 1916. (See JOURNAL OF THE RÖNTGEN SOCIETY, Vol. XII., No. 48/83). He, as well as the last speaker, gave a warning that Ultra-violet light was not a universal panacea for all kinds of things. He doubted if anything was gained by saturating the carbons with a solution instead of coring them with a suitable metal, as tungsten, etc.

Both the oxide of tungsten and the powdered metallic tungsten were used; both are equally efficacious. In either case a paste is made of the powdered oxide or meta and duly rammed into the core of the carbon and allowed to dry. Such a cored carbon may be prepared at a fraction of the cost of the Wolframite carbons used by Mr. Simpson. There is less spluttering, very much less vapour, while the amonnt of ultra-violet rays generating is very large, and as a spectrogram shows, the radiations extend to 2,000 Angström units.

Dr. SIDNEY RUSS: There are many points in Mr. Schunck's communication in which I am interested, but I am going to confine my remarks to one only, and that is to join issue with him over a crucial point. The facts that have emerged in the years of experience with ultra-violet light show that the radiations of wave-lengths between λ 2100 and about λ 3000 have a marked effect on the skin. Radiations within this range produce the so-called erythema. Both Mr. Schunck's experiments on his arm and the experiments of Dr. Sequeira also on his arm go to show that if you cut off these rays —which you can do by a layer of skin $\frac{1}{10}$th mm. thick—you do not get erythema. Therefore Mr. Schunck says that the main therapeutic effects are to be associated with this range of wave-lengths. I am not convinced of this, however, because in the first place I think we have to admit the possibility of physiological action proceeding at a depth, owing to the stimulus at the surface provided by these rays. In the second place, it cannot be assumed that the rays of longer wave-length than λ 3000

* The extreme radiations in the ultra-violet, it must be noted, are lost in the reproduction of the plates.

have no action upon the tissues through which they pass. The erythema produced is no measure of such radiation; hence I think it inadvisable at the present stage to suppose that the therapeutic efficiency of any ultra-violet radiation can be measured by its power to produce erythema.

Mr. J. H. GARDINER: We can congratulate Mr. Schunck upon the excellence of the spectrograms he has shown us, and I am quite sure that when we get them reproduced in the Journal they will be used for a long time to come as a reference to tell us and those gentle men who are using ultra-violet radiation for therapeutic purposes exactly the kind of radiation which is being employed. The subject is an exceedingly interesting one, and a very old one. As long ago as 1903 I did a little in the way of investigation, and read a paper before this Society on the same subject as the one brought forward to-night.* The point that occurs to me as a non-medical man—and I have no doubt occurs to a good many others—is this: there is no question about the advantage and utility of ultra-violet radiations, but the problem we have got to solve is to be quite sure what kind of radiation and what wave-length is producing the effect we observe. In the case of luminous radiations the matter is very much more simple than it is in the case of X-rays. With luminous radiations it is quite possible to command any kind of radiation one wants, and therefore there is nothing to prevent careful experiments being made to determine exactly what physiological properties follow any particular kind of radiation; and for that purpose the charts or maps we have had before us to-night, and which I hope will be our property for the future, will be of the greatest possible value. I would like just for a moment to place on the black-board something that I pointed out in my paper before the Society in 1903, and which, I see, is confirmed by Mr. Schunck's spectrograms to-night. In the case of the Finsen light the wave-length λ 5000 was as far as I could go to at that time, for the panchromatic plate was not then on the market. The Finsen light had a maximum of intensity which fell off rapidly below λ 4000. But the lamp at St. Bartholomew's, which was the iron spark, gave a concentration at λ 2250—a concentration which was almost as great as the concentration in the visible part of the spectrum with the carbon arc. I noticed on the first spectrogram Mr. Schunck showed us that there was a similar concentration in his iron spark. It was so very marked that possibly most of those present will recall it without the necessity of projecting the slide again. Here we have two readily available sources of radiation. With a carbon arc we can obtain a great concentration of light in the visible part of the spectrum, while, on the other hand, if we take the condensed iron spark, we can get a concentration of radiation of quite a different wave length. It would be a grand thing if it could be decided definitely what effects are produced by these two different kinds of radiation. I fully appreciate what the first speaker in this discussion had to say about the difficulty of getting metallic tungsten. That it is difficult I know from experience, but I do not think we need be discouraged about that. Iron will do a very great deal. All the spectrograms exhibited to-night have shown it, and we can get iron without any difficulty at all. A carbon impregnated with uranium will give a great concentration just between the two positions I have spoken of, the carbon arc and the iron spark. So that we have everything in our power to make some specific experiments. After Mr. Schunck's paper to-night it will be much easier to carry out some really careful work on the subject and I do not think that lack of tungsten need deter anybody from making them.

* Archive of the Roentgen Ray, May, 1903.

Dr. G. B. BATTEN: I should like to support Mr. Gardiner with regard to iron electrodes, probably in the form we were accustomed to use them some years ago, in the way of the condenser discharge lamp. I have one at home, and also an iron arc lamp with a quartz window. The chief reason why these

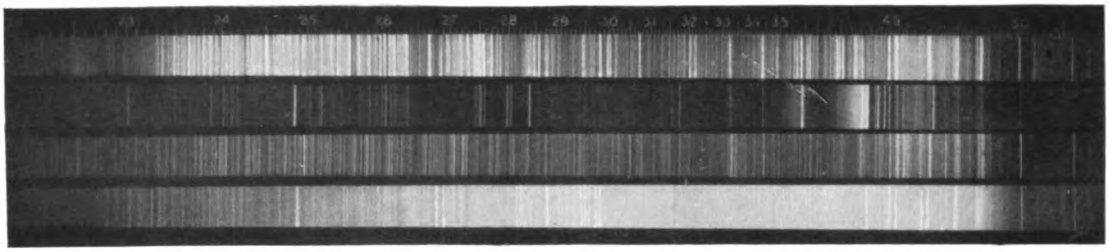


Fig. A.
1.
2.
3.
4.

Spark Spectrum of (1) Iron, (2) Carbons, (8) Tungsten, (4) Jones Electrodes. (4 amps., 5 min. exposures).

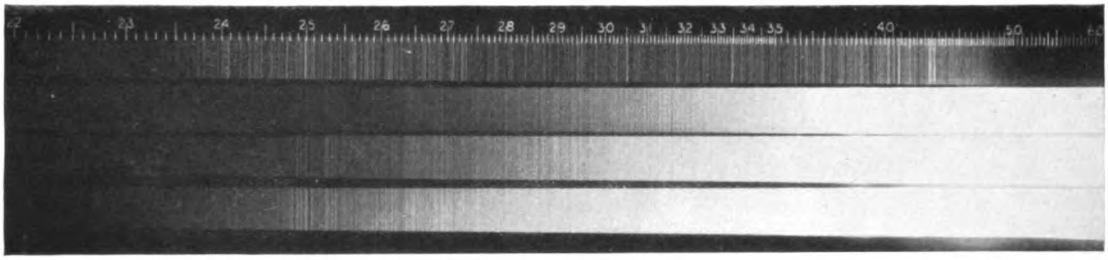


Fig. B.
1.
2.
3.
4.

Art Spectrum of (1) Tungsten, 15 sec. exposure, (2) (3) (4) Jones Electrodes 15, 30, 60 sec. exposure (amps. 5).

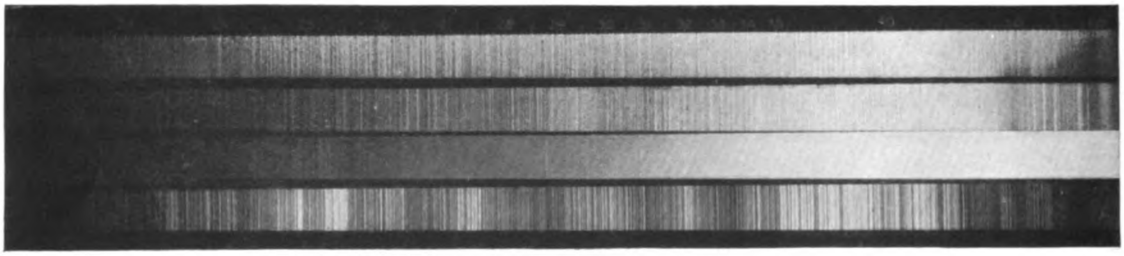


Fig. C.
1.
2.
3.
4.

Arc Spectrum of (1) Tungsten, (2) Molybdenum, (3) Uranium, (4) Iron. (6 amps., 15 sec. exposures).

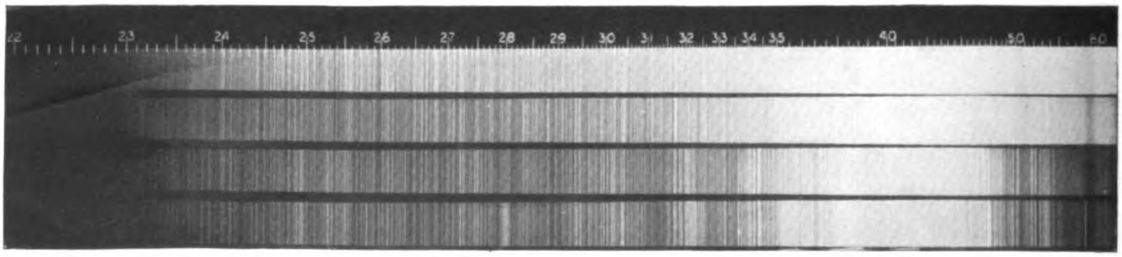


Fig. D.
1.
2.
3
4.

Arc Spectrum of (1) Tungsten, (2) Carbons Tungsten-cored, (3) Simpson electrodes, (4) Carbons Wolfram cored. (8 amps., 15 sec. exposures.)

PLATE III.

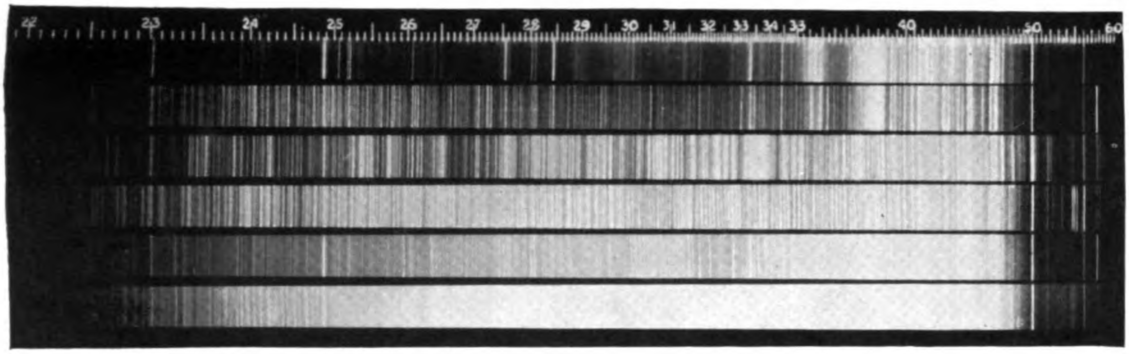


Fig. E.

1.
2.
3
4.
5.
6.

Spark Spectra of Impregnated Carbons. (1) Carbon, (2) Sodium Tungstate, (3) Titanous Chloride, (4) Ammonium Molybdate, (5) Uranium Nitrate, (6) Jones Electrodes. (4 amps., 5 min. exposures).

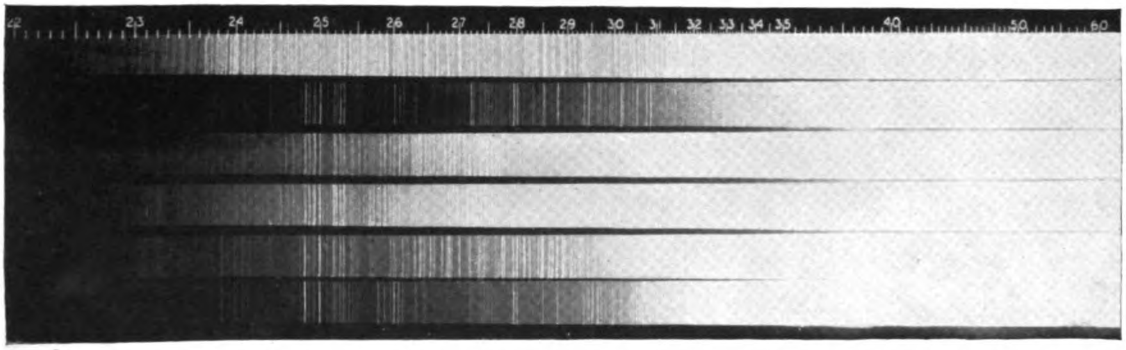


Fig. F

1.
2.
3.
4.
5.
6.

Arc Spectra of Impregnated Carbons. (1) Tungsten Electrodes, (2) Sodium Tungstate, (3) Uranium Nitrate, (4) Jones Electrodes, (5) Ammonium Molybdate, (6) Titanous Chloride. (6 amps., 30 sec. exposures).

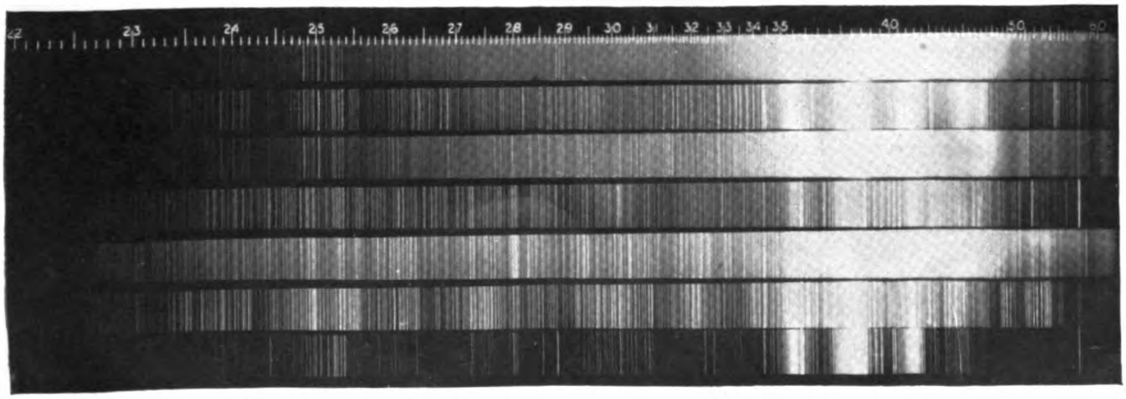


Fig. G.

1.
2.
3.
4.
5.
6.
7.

Arc Spectra of Cored Carbons. (1) U_3O_8, (2) Molybdenum powder, (3) Jones Electrodes, (4) Tungsten powder, (5) Wolfram, (6) Fe_2O_3, (7) Carbons. (15 sec. exposures, amps 7).

Plate IV.

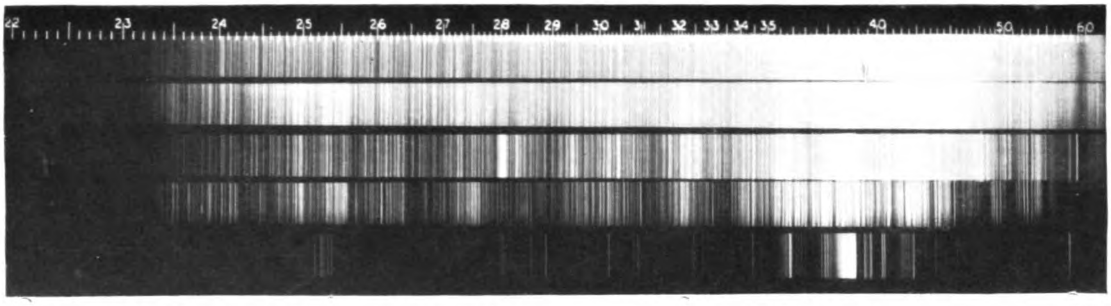


Fig. H.
1.
2.
3.
4.
5.

Arc Spectrum of (1) Tungsten, (2) Simpson electrodes, (3) Wolfram-cored carbons, (4) Iron, (5) Carbons. (10 sec exposures, amps. 7.)

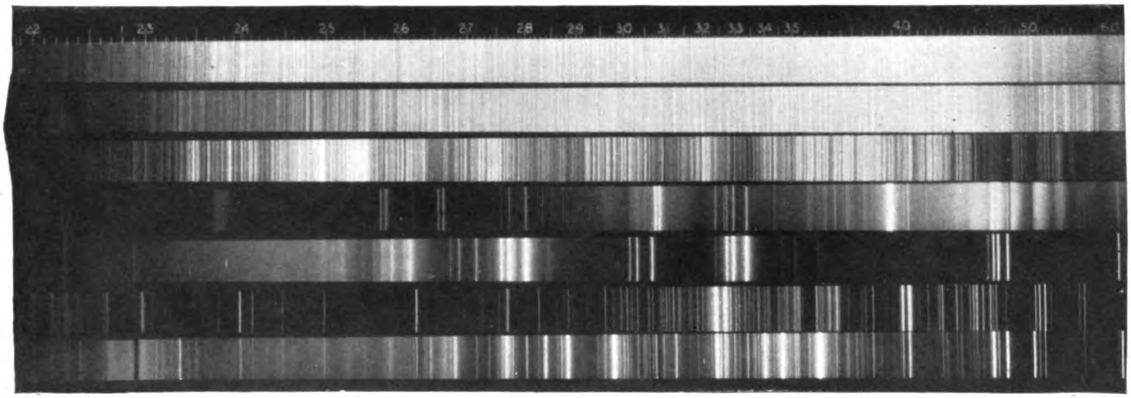


Fig. J.
1.
2.
3.
4.
5.
6.
7.

Arc Spectra of (1) Tungsten, (2) Molybdenum, (3) Iron, (4) Aluminium, (5) Zinc, (6) Copper, (7) Cadmium. (8 amps., (1) 5 sec., the others 10 sec. exposures).

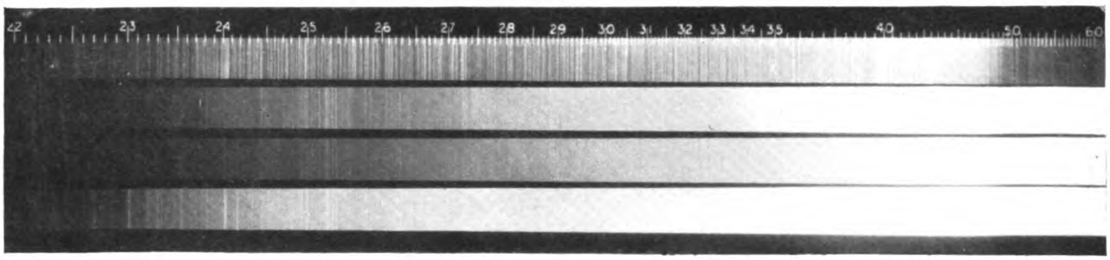


Fig. K.
1.
2.
3.
4.

Arc Spectrum of (1) Tungsten, 15 sec. exposure; (2), (3), (4). Uranium. 30, 15, 60 sec. exposures. (Amps. 6).

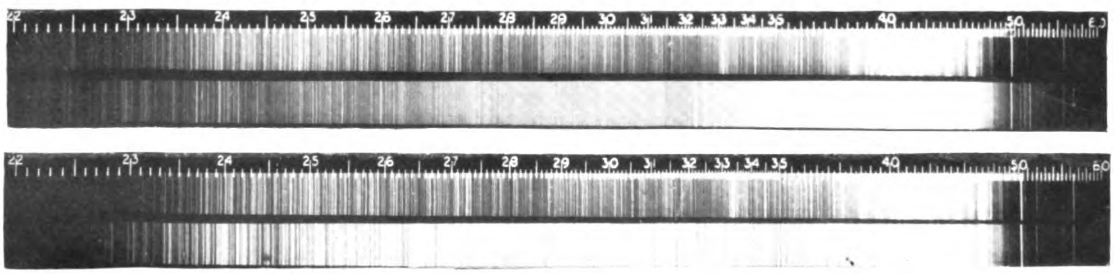


Fig. I.
1.
2.
3.
4.

Spark Spectrum of (1 & 3) Tungsten, (2) Uranium, (4) Molybdenum. (4 amps., $2\frac{1}{2}$ min. exposures).

PLATE V.

iron arc lamps failed in therapeutic value was because they were too small. The ampèrage was small. They were really nothing more than toys. I would also like to support Dr. Russ in his contention that it is not the erythema that does the good, for if it were, a mustard poultice would do as well.

Mr. SCHUNCK, in reply, said: The reason why I made these experiments with one tungsten and one carbon to get the therapeutical effect and then took a spectrogram was in view of what Major Wilson had told us about his lamp. Spectroscopically one gets almost as good an effect with one tungsten and one carbon as with two tungstens. Mr. Gardiner mentioned an iron arc, which he said was water-cooled. A good deal of caution should be exercised when cooling the source for ultra-violet light treatment, water having a certain absorptive power for ultra-violet rays. I have made experiments with the spark of the Jones electrodes (carbons impregnated with uranium nitrate and ammonium molybdate) and I have found that if you use anything more than 1 cm. of water you cut out the ultra-violet below λ 3000. Mr. Gardiner said he referred to water-cooling inside the poles (the water circulated within the iron itself). Mr. Schunck said that what he had just stated did not, of course, apply to such an arrangement. Continuing, he said: With regard to what Dr. Russ has stated, namely, that the therapeutic effect may not be a surface one, I should like to point out that the medical side of this question is not my province. My therapeutic experiments were based upon the erythema effect alone, as suggested by Major Turrell, and the question as to what really is the cause of the curative effect I cannot deal with. With regard to the spark spectra for ultra-violet light treatment, I do not know whether it has ever been used extensively, but for treating very small areas with a condensing lens there is no reason why it should not be tried. The best source of light would be the carbons impregnated with uranium nitrate and ammonium molybdate. You simply boil them first, in an ammonium molybdate solution for an hour or so, and then boil them in a uranium nitrate solution, take a spectrogram, and if not intense enough, boil them up again. The spark spectrum next most intense is iron. The maximum radiation is not found in the arc (to which Mr. Gardiner drew attention) at the same position as in the spark, being shifted to about λ 2500. Anybody who possesses an X-ray coil has a suitable apparatus at hand. The coil I use for spark spectra is 10 in.; with a 16 in. X-ray coil, now generally used, one would get an intenser spark. One simply joins up the alternate spark-gap-terminals to the spark electrodes—the sparking distance of which is about 5 mm.,—and puts in in parallel a condenser of the Leyden jar type; it need not be actually a Leyden jar, but a box of three or four glass plates, 10×9 inches, covered with tinfoil. Three of these plates in parallel will give a sufficient capacity; with more than three no increased effect is obtained.

ADDITIONAL NOTE.

Read March 6th, 1917.

Since my last communication on the subject I have made one or two observations and experiments that may be of interest to record. In "Science Abstracts," No. 1129, are given the X-ray Spectra of the Elements from Sodium to Chromium by M. Siegbahn and D. Stenström, from which Na gives the softest X-ray so far recorded, *viz.*, 11·951 A.U., so the unexplored region now is further extended from the X-ray region, the former limit referred to being the aluminium line 8·360 A.U.

I am now able to give the result of the analysis of the Simpson electrodes compared to the Wolfram I used in the cored-carbons, which has kindly been carried out for me by Mr. J. P. McCarthy at the Oxford Chemical Laboratories. His figures are:—

SIMPSON ELECTRODES.

WO_3	= 73·22%	=	58·83% W
FeO	= 6·588%	=	5·12% Fe
MnO	= 17·110%	=	13·25% Mn
SiO_2	= ·462%	=	
Residue ...	= 2·118%		

WOLFRAM.

WO_3	= 74·42%	=	58·55% W
FeO	= 18·65%	=	14·49% Fe
MnO	= 4·207%	=	3·26% Mn
SiO_2	= ·529%		
Residue ...	= 2·194%		

(The residue consists of Mg, Ca, Sn, Nb and Ta).

The result shows that the tungsten content is practically identical, while the proportions of iron and manganese are reversed.

I showed you last January a slide exhibiting the spectra of the sources used in treatment taken with the same exposures and ampèrage for each so as to compare the radiations in the sources and their relative intensities approximately (Plate 5, Fig. H). I will now show you a slide exhibiting each spectrum approximately of equal intensity by giving a suitable exposure to each. The Tungsten electrodes and the Simpsons were given an approximate exposure of one second each; the Wolfram cored carbons and iron 10 seconds and the carbons 30 seconds, the ampèrage being six throughout, which brings out very strikingly the different intensity of the sources as judged by the time of exposure given.

From a comparison of the spark and arc spectra of several metals it will be seen that W, Mo and Fe contain very many more radiations and more continuous than Cu, Al, Zn, or Cd, more especially in the arc, and are therefore much more applicable for treatment. Plate 5, Fig. L, compares the spark spectra of W and Mo, the latter appearing more intense. Of the arcs (Plate 5, Fig. J) the Al and Zn electrodes burn away too rapidly to be of any service at all, the Cu quite steady, but the Cd electrodes are too brittle, breaking off as the discharge takes place. In the Cd spectrum will be noticed an interesting reversal at λ 2290, these reversals of a line being of not uncommon occurrence in arc spectra.

Through the courtesy of Mr. H. A. Kent, the well-known metallurgist of rare metals, I obtained a small quantity of pure uranium which has enabled me to examine its spectrum in the spark and arc. Plate 5, Fig. L, gives the spark spectrum compared to Tungsten and Plate 3, Fig. C, the arc spectrum, together with Tungsten, Molybdenum and Iron. It will be noticed at the same ampèrage and exposure the metallic U spectrum does not extend so far or is so intense as W, Mo or Fe; but giving an increase of exposure, it almost equals in extent that of W, is as intense and the numerous lines are so close together as to give the appearance of a continuous spectrum. (Plate 5, Fig. K.) Two dark lines will be noticed in spectrum 3 of Fig. K at about λ 3250; these are due to the two characteristic Cu arc lines reversed. They are also visible in spectra 2 and 4, but less intense. Unfortunately I had not enough material for a therapeutical experiment, but judging from the intensity of the spectrum compared to W at the same ampèrage and exposure no better results can be expected than the carbons impregnated with uranium nitrate and ammonium molybdate—the Jones electrodes—Plate 3, Fig. B, which did not amount to much.

A comparison was made of the Tungsten spectrum at different ampèrage (4 and 8) and exposures (5, 10, 15 seconds) to see if any additional radiations appeared at the high ampèrage and whether an ampère-second exposure is constant. A careful examination of the plate does not reveal any additional radiations at the higher ampèrage, and a higher ampèrage and less exposure appears to give an intenser spectrum than *vice versa*, the ampère-seconds being constant. This is borne out by the therapeutical effect, the erythema produced on my arm by the W. arc in 2 m. at 8 ampères being considerably greater than 4 m. at 4 ampères. Major Turrell informs me that this is the general experience clinically—that a higher ampèrage has a greater effect.

An experiment was made with $\frac{5}{16}$-inch bars of high-speed steel, containing 17 to 20 per cent. Tungsten as used for tools; the spectrum, however, was that of iron with only a few Tungsten lines recognisable. They burn very steadily in the arc and do not scintillate as much as iron. The erythema effect is slightly greater than

with iron electrodes, but clinically Major Turrell has found them of small effectiveness compared to Tungsten.

I have been able to examine the radiations given by the Pointolite lamp enclosed in quartz, which has been arranged by Messrs. Cox & Co. for Major Turrell to try clinically. In connection with it is a resistance for the voltage under use, the ampèrage when the arc is running being 1·5 ampères. It is an ingenious device of Mr. Mullard's to obtain an enclosed Tungsten arc without the Tungstic oxide white fumes, the atmosphere inside the quartz bulb being nitrogen and it is claimed for it as being a convenient source of ultra-violet rays for therapeutics. The spectrum, however, at 1·5 ampères, contains apparently no Tungsten radiations at all; the spectrum which extends to about λ 2800 being a continuous one, as given by an incandescent solid with the positive pole band spectrum of N comprising the second group, with heads at λ 3900, λ 3576, λ 3380, λ 3160 and λ 2980, together with a conspicuous line at about λ 2548, which may be due to Argon. As arranged for 1·5 ampères it is therefore ineffective as an ultra-violet radiation source therapeutically. Mr. Morphy, however, stated in the paper he read on the lamp at the April meeting last year* that when the current is increased to 4 ampères the output of ultra-violet radiation is of the same order as the open Tungsten arc. Major Turrell has tried the lamp clinically without any result, giving 5 m. exposures, and an exposure of 4 m. (twice that used with Tungsten) on my arm in the usual manner, with the cylindrical condensing lens, likewise gave no erythema. I hope shortly to experiment with the lamp at increased ampèrage.

I thought that, as in the Finsen light treatment, the arc radiations were passed through a quartz cell of water to absorb the heat rays, a device which Major Wilson stated he used in connection with his Tungsten arc lamp†; it would be interesting to ascertain the absorption by water of the radiations from the Tungsten arc. It may be stated that the rise in temperature due to the heat of the Tungsten arc from $\frac{1}{16}$-inch rods with 8 ampères at a distance of 12 inches, room temperature 56·5°F. in five minutes, was ascertained to be only 3°F. No doubt with the powerful arc lamps used by Finsen and the radiations concentrated by lenses on the skin, the rise would be greater. Distilled water specially prepared at the Oxford Chemical Laboratories, giving a zero conductivity in thicknesses of 1 to 10 cm, appeared to be completely transparent throughout the entire extent of the visible and ultra-violet regions to the radiations from the Tungsten arc, whereas Oxford tap water, thickness 10 cm., cut off the radiations from λ 2350, with 5 cm. from λ 2250 and with 1 cm. from λ 2200 approximately, the Tungsten spectrum extending to λ 2140. These limits were the same either at 15 seconds or 2 minutes' exposure with the condensing lens, so the absorption is not great. With the pure water there was no difference in the erythema produced compared to the Tungsten arc, but with 5 cm. and 10 cm. of Oxford tap water interposed between the arc and the skin, there was some difference with 10 cm., while at 5 cm. very little difference could be detected compared to the arc alone. This tentative experiment tends to show that Tungsten radiations shorter than 2250 A.U. have little therapeutical value.

Carbons cored with Molybdenum metallic powder gave no therapeutical effect and others cored with Titanium di-oxide only a slight erythema under the usual conditions, nor did the Tungsten spark give a reaction. But carbons cored with Tungsten metallic powder gave a good reaction, though not as great as the merallic Tungsten electrodes, but increasing the ampèrage of the cored carbons to 15, compared to the latter at 9, there was but a slight difference in the intensity of the erythema produced in 2 minutes, with the sources concentrated on the skin with the cylindrical quartz lens, both being intense. So carbons cored with Tungsten powder, which is procurable, should prove an effective substitute if the metallic rods are not obtainable, provided that a higher ampèrage than can be used from an

* Röntgen Society Journal, Vol. xii., p. 70, 1916.
† Röntgen Society Journal, Vol. xii., p. 83, 1916.

ordinary electric lighting circuit is arranged for with suitable fuses. The Tungsten powder cored carbons appear to be the most effective I have experimented with. It is only necessary to have the soft core of the carbons taken out and then fill with the substance, shaking and ramming down well and when the arc has once passed the powdered metal at the poles is fused and thus prevents the powder in the core of the carbons from falling out.

Major WILSON suggested that in view of the cost of metallic tungsten electrodes, equally good effects could be produced by one metallic electrode and the other a carbon electrode cored with tungsten powder.

Mr. GARDINER referred to the unfavourable spectogram that Mr. Schunck had obtained with the Pointolite Lamp, and asked if Mr. Schunck was sure that it was a quartz bulb, and, if it was, did he notice whether there was any deposit on the inside of the bulb, because he had found experimentally that such deposits would obscure radiations of a very short wave length.

Mr. SCHUNCK: In reply to Major Wilson, I think I showed in my last communication that one can certainly halve the expense of metallic tungsten by using a tungsten rod as positive and a cored carbon as negative. Carbons cored with tungsten powder, with increased current, give almost the same effect as tungsten rods. As to the "Pointolite" lamp, Mr. Morphy can inform us about the quartz bulb and its possible coloration. It was a lamp made recently for Major Turrell. The only explanation that occurs to me is that the heat is not great enough, or it may be the atmosphere—the nitrogen. But even with $1\frac{1}{2}$ amperes the tungsten open arc gives radiation to $\lambda = 1,140$.

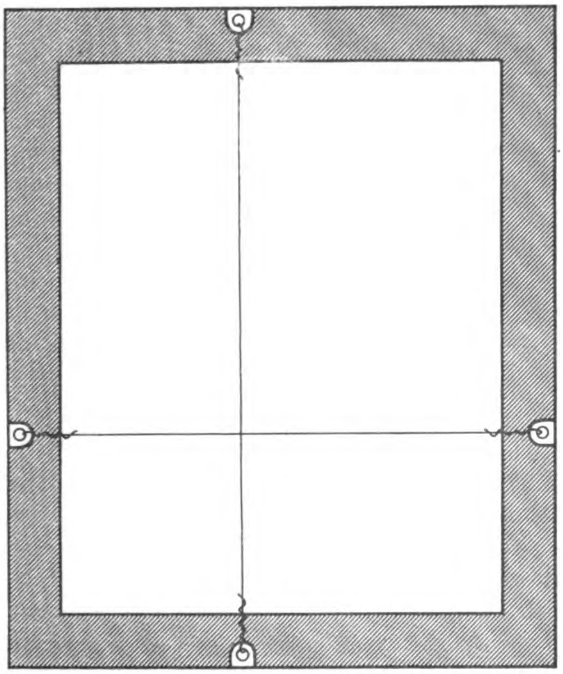
Mr. MORPHY, speaking at Mr. Schunck's suggestion, said that when the "Pointolite" lamp was tried with four ampères, the spectrum extended very much further. The quartz lamp was sent to Major Turrell to try, but it had certainly been used a good time beforehand, and with heavy currents, so that he was not certain as to the presence of coloration on the inner surface. It was quite possible that there was coloration, and that it was sufficient to stop the short wave-lengths.

Major W. J. TURRELL, while emphasizing the value of Mr. Schunck's investigation, pointed out that the work was really the result of some observations made by Dr. Sidney Russ at a meeting of the Royal Society of Medicine. The question that had come up in discussion as to the value of the erythema effects as a guide to the clinical efficiency of ultra-violet radiation was an important one, and he hoped that it would be fully discussed in a future communication.

A SIMPLE CROSS-WIRE FRAME FOR USE IN LOCALIZATION.

Dr. G. B. BATTEN showed a simple cross-wire frame for use in ocalization. He said that he was well aware that cross-wire devices in which the wires were adjustable were quite old, but these were generally parts of a rather elaborate apparatus. He did not wish to bring forward his own little device as a thing to supersede these others, but merely to afford a means of enabling the worker to have at hand some simple assistance in localization. Most of the cross-wire arrangements supplied were either embedded in cardboard or in wood in a kind of picture-frame arrangement, and one could not see where the wires were except by the markings on the surface put to indicate the position. He had made a simple little device to get over this difficulty. He used either photo-mounts or the cardboard frames which were obtained from the cassettes supplied with accelerating screens (if preferred, metal could be used), and upon these he arranged the cross-wires in such a manner that they could be readily moved. The device, he claimed, had four advantages over those ordinarily supplied. Most of those

cross-wire arrangements furnished for localization had the cross wires intersecting in the middle of the frame. With the adjustable wires, however there was an advantage in localizing, for instance, a bullet situated in such a position as the outer part of the thigh, for with the frame in which the cross wires were made to intersect in the middle, a large portion of the plate was necessarily wasted in centring, while with the adjustable wires the cross wires could be centred over the bullet and yet



Metal or Cardboard Frame with movable wires.

the plate could be put where one pleased and the whole of it made useful. The second advantage was that the wires could be used directly on the patient, and inked with Indian ink, so that, if between the exposures they were moved out of place, the correct position could easily be recovered owing to the marks on the skin. The third advantage was that the wires could be sterilized very easily, and this was of great value since one was constantly localizing over septic wounds. It was easy to sterilize these wires over a spirit lamp, or even an ordinary match would be sufficient. This match method of sterilization might even render Indian ink unnecessary, for the lamp black from the flame on the wires was sufficient to make the marks on the skin. The fourth advantage was cheapness. He used photo mounts and fastened the ends of the wire to little metal clips which are sold with the boys' toy called meccano, and the clips can easily be bent over for the given thicknesses of cardboard. As to the wire, personally he did not like very thin wire, because it could not be seen very easily on the screen. He had made another variety of frame with a view to facilitate matters when it was required to put the plate under the patient. He had a celluloid frame with three slightly raised sides and by putting this wire device on the back of it, wires upwards, one was able to slide the negatives in and out and also to move the wires into the desired position easily.

He had found this device very useful in localizing foreign bodies in all sorts of positions in the body, and the marks of the cross wires on the skin, which were afterwards rendered more permanent by nitrate of silver pencil, were found valuable by the operating surgeons. The greatest use was, however, for the combined method adopted in many hospitals of taking two stereoscopic plates and localizing the depth of the foreign body by the movement of its shadow from one or other of the crossed wires on these two stereoscopic plates; one was able both to see the position of the foreign body by the stereoscope and mathematically to calculate its depth.

Captain S. N. FINZI said that without wishing in any way to detract from the ingenuity of the device shown, he would like to make one or two criticisms. In the first place, cardboard was hardly rigid enough for such a frame; metal was better. In the second place, the movable wires had the disadvantage that one tended to get them out of the right angle. It was difficult to superpose the two plates correctly. He had at the beginning of the war three or four frames of a similar kind, and he

found them interfere with the accuracy of delicate localizations, as, for instance, in the eye. As one usually centred right over the foreign body, he did not think it a disadvantage to have the wires fixed and intersecting in the middle of the frame.

Dr. BATTEN, in answer to Captain Finzi, said that he would never dream of using this device for localization in the eye, where, of course, a special apparatus was necessary. It was simply for less minute localizations in other parts of the body. The frame made in metal had the disadvantage that some secondary radiations might be produced. Also occasionally he used this frame under a larger plate with an accelerating screen and the cardboard ***did not*** show, whereas a metal frame would. He had found the cardboard he used quite stiff enough for all practical purposes.

RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Institution of Electrical Engineers on Tuesday, February 6th, 1917, Captain Thurstan Holland, M.R.C.S. in the chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society:—R. W. PYNE, B.Sc. Dr. FOURNIER D'ALBE, D.Sc., Dr. W. N. KINGSBURY, Dr. D. MORROW, M.R.C.S., L.R.C.P.

NOMINATIONS.

H. D. GEORGE, Dispenser, Poplar and Stepney Asylum, Poplar.

Proposed by W. E. SCHALL.
Seconded by W. E KINSMAN.

LIEUTENANT R. CASMAN, Medicin du 7m Regiment d'Artilleriele Arme Belge, late Radiographer Elizabeth Hospital, Antwerp, Canadian Division, B.E.F.

Proposed by A. E. DEAN.
Seconded by R. KNOX.

DR. R. OSBORN SMYTH, 9, College Hill, Shrewsbury.

Proposed by HOWARD C. HEAD.
Seconded by R. KNOX.

J. C. WILSON, Engineer, 9, Woodville Road, Blackheath, S.E.

Proposed by HOWARD C. HEAD.
Seconded by R. KNOX.

HENRY THOMAS PAGE GEE, Chartered Patent Agent, 70, George Street, Croydon, Surrey.

Proposed by CHARLES W. RAFFETY.
Seconded by H ANNESLEY ECCLES, M.D.

The PRESIDENT said that it might interest the members to know that the financial position of the Society was very satisfactory. It had been decided to invest £300 in 5 per cent. War Loan and after doing that there would remain at the end of the financial year a balance of about £90.

SOME PROPERTIES AND APPLICATIONS OF SELENIUM.

By E. E. FOURNIER D'ALBE, D.Sc.

Mr. President, Ladies and Gentlemen,—The element with which I shall deal to-night is one of those rarer elements which stand on the threshold between metals and non-metals. Selenium, so called after Selene, the Greek name for the Moon goddess, was discovered by the Swedish chemist Berzelius in 1817, so that this year is the centenary of its discovery, a fact worth bearing in mind. It is now obtained from the mud found in the lead chambers used in the manufacture of sulphuric acid, usually by the action of sulphur dioxide on selenious acid, according to the equation $H_2SeO_3 + 2SO_2 + H_2O = Se + 2H_2SO_4$.

Selenium is closely allied to sulphur as a non-metal and on the other hand to tellurium, an element of distinctly metallic character. But while tellurium is a good conductor of electricity, sulphur is the best insulator we have. Selenium has practically no electrical conductivity in the state in which one ordinarily sees it, but if

brought near its melting point and kept there for some hours it is converted into a grey crystalline state which has some conductivity, but not very much, the resistance being of the order of a megohm to the centimetre cube.

Up to the year 1873 selenium was regarded as an element of minor chemical interest, but what we may call an accident led to the discovery of its remarkable property of changing in electrical resistance under the action of light. It was the poor conductivity or high resistance of selenium which led the authorities of the Valentia Island cable station to use it in some cable testing experiments. I believe it was Inspector May of that station, a young assistant, who made the observation that this substance was not satisfactory as an insulator on account of the action that light had upon it ; thus for measuring purposes, of course, it was useless.

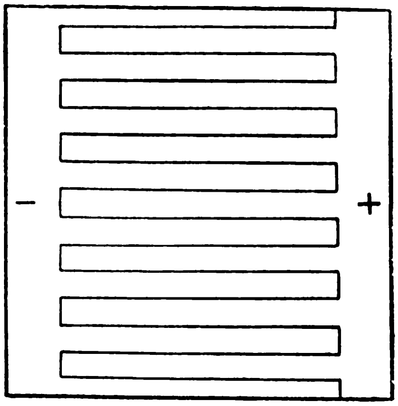


FIG. 1.

Willoughby Smith was greatly interested in this phenomenon, and after investigation described its properties before the Royal Society ; so that the discovery of the most remarkable property of this element is British and dates from the year 1873.

One might expect that such a property, once its importance was realized, would attract a great amount of attention, and so it did at the time, Willoughby Smith and Adams working on it in this country (Proc. Roy. Soc., 23, 1875, p. 535), and W. Siemens in Germany (Pogg. Ann. 156, 1875, p. 334). Eventually, however, the interest died down. When Graham Bell in America by its use succeeded in transmitting speech, not along a wire, but along a beam of light, attention was once more directed to selenium. It was the year 1880 which saw this invention of the "Photophone": another epoch

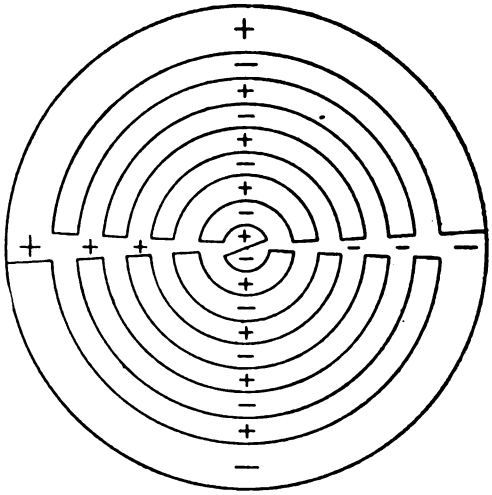


FIG. 2.

was marked in 1901 by the discovery of the speaking arc, which opened up a very much greater range for the action of the photophone ; and then in 1902 came photo-telegraphy—the successful telegraphy of pictures along a wire.

As I have already said, selenium has a high resistance, and it is necessary for practical purposes to reduce this resistance by giving the selenium conductor a very large sectional area and reducing its length. At the same time we must have a large surface exposed to light. In all the so-called selenium "cells" which have been devised, the design has been governed by these guiding principles. Figs. 1 and 2 show two methods of construction, one square, the other round, the first my own, and the second due to Presser.

The square form is the more simple of the two. The base is a porcelain plate, which is covered entirely by graphite, and then, by means of a diamond, grooves are engraved upon it to and fro in the manner shown in the

illustration, and finally the whole surface, save for the two margins on either side marked + and —, is covered with selenium, which fills the grooves. That is the method which I have adopted in practically all my " cells," or selenium " tablets," as I prefer to call them. The other construction, due to Presser, consists of steatite as a base, which is covered first with a layer of platinum in which circular grooves are engraved, and the whole surface is then covered with selenium.

I should like also to refer to a cylindrical cell constructed by Ruhmer, the inventor of the arc photophone. In this case we have an insulating cylinder wound with two parallel spirals of wire, and smeared over with selenium; this is then sensitized in the usual way and the whole is enclosed in an exhausted bulb.

These, then, are three types of the various contrivances which have been used for making selenium cells. Those who have studied the literature of the subject since 1875 will be astonished at the great variety of devices adopted. I need only mention a very few. Graham Bell used perforated copper plates; one of the copper plates was fitted with studs fitting loosely into the holes drilled in the other. The latter was smeared over with selenium, which filled up the circular grooves between the studs and the holes; also he used cylindrical sheets of copper and mica. Then we have Shelford Bidwell's construction, in which mica or slate was wound with platinum or copper wire, and then the selenium applied.

To turn to a quite different construction, we have that of Fritts, who used a gold plate covered smoothly with selenium, and then this selenium was covered by a layer of gold leaf. The idea was that the gold leaf would be sufficiently transparent to make the whole area available for developing the photo-electric effect.

Then there was Liesegang, who devised the simplest construction of all; silver was deposited on a glass plate, and in that silvering was a slit, which arrangement of course was very useful for such things as spectroscopic experiments.

Still other types of cells are those due to Sabine and to Minchin. In this case another property was made use of, namely, the generation of an E.M.F. in a voltaic cell in which selenium was an electrode. These, which can properly be called selenium cells, were used in rather an interesting manner for photometrical purposes; Minchin succeeded by means of such cells in measuring electrically the brightness of the brightest stars, Jupiter, Venus and Capella. (Roy. Soc. Proc., 58, 1895, p. 142, and 59, 1896, p. 231). Various other cells have been projected, including Siemens' use of platinum wire spirals between mica, Weinhold's glass cylinders wound with spirals, and Mercadier's brass strips, all originating, like most of the others of which I have spoken, within ten or twelve years after the light action of selenium had been discovered. The square and circular constructions of which I have given diagrams, however, only date from 1911 and 1909 respectively.

NATURE OF THE LIGHT ACTION.

Now I must sav a few words about the theory of this action. I have read in quite a recent book on selenium that the nature of the light action is unknown. That is rather a despairing view. I myself believe that we are very close to a full elucidation of the nature of this very mysterious action. I show a slide giving a curve to illustrate the manner in which the conductivity of selenium on exposure rises and falls in darkness. The illustration is from a book published by Ries. It will be observed that the conductivity increases six times and the curve rises very rapidly at first; after fifteen minutes' exposure the limit of conductivity is reached; then the light is turned off, and we get the recovery curve which falls rapidly at first, but never within this range of experiment reaches the original point. The recovery is always much slower than the light action. The curve furnishes a view of the general course of events when the selenium is exposed to light. As long ago as 1881 it was suggested—no more than guessed—that this action was entirely due to heat. This theory was put forward by Moser. But it is not so, because the effects are very much larger

than one could possibly explain by any absorption of the heat available. Moreover, the action is only reduced very slightly by putting the whole cell into liquid air having a temperature of—180 deg. C. Sale thought it due to action on intramolecular ether; and Bidwell, who was a great authority on selenium (he was the first man to ring a bell by means of a beam of light) thought the whole effect due to the formation of selenides at the electrodes. That is certainly erroneous, because if one takes a long strip of selenium which has only electrodes at the extreme ends and exposes the middle portion to light, one gets an effect in proportional to the area exposed. A number of other theories have been ventured. Himstedt suggested fluorescence as connecting light and electricity. Then chemical theories were adhered to for some time by various workers. Anyone who reads the treatises which attempt to carry out those theories will be appalled by the number of fractional coefficients which have to be introduced in order to account for the phenomenon.

I think it is quite natural to suppose, in the light of recent physical research, that some kind of ionization theory should be propounded, and this, I believe, will be the final solution of the whole question. I believe the light action to be due to the liberation of electrons or other ions within the selenium. I made some attempt to follow up the matter, and so far as that attempt has gone it has accounted for the facts completely in respect to illuminations below one metre-candle. When one gets higher illuminations other effects such as heat, etc., come in. But it will be quite understood that if we can reduce the phenomenon to ionization we link it up with all that is known with regard to the ionization of gases and the effects of ultra-violet light in splitting up atoms. This reduces us to two simple facts, first, that the number of ions produced is proportional to the incident energy (the intensity of the light,) and secondly, that the re-combination of these ions takes place in accordance with a simple exponential law which governs all such cases, the re-combination being proportional to the square of the number of ions present. The recovery curve is governed by that law, and if upon that be superimposed the exposure curve, we get hold of the action theoretically. The equation to the light-action curve is

$$dN/dt = C—BN^2$$

where N is the number of new ions present (measured by the additional conductivity). C is the flux of incident energy, and B is the coefficient of re-combination.

By integration we get

$$N = \sqrt{(C/B)} \tanh (t\sqrt{C})$$

a hyperbolic tangent curve which fits the light curve accurately for moderate or feeble illuminations. From these two laws certain things result at once. We can determine beforehand what is the best way of arranging our cells so as to get the maximum effect from very small quantities of light, and we can predict what would be the action of very faint light.

MINIMUM LIGHT DISCOVERABLE.

Is selenium capable of discovering light invisible to the eye? One of the results of the ionization theory is this, that the total effect one can expect from any given quantity of light is proportional to the square root of the illumination. That is discouraging when one comes to very strong illuminations, but it is extremely encouraging in the case of feeble illuminations. If a strong illumination be reduced 10,000 times, one will get, not 1/10,000th of the current one got before, but as much as 1/100th. A sufficient time must be allowed, however, for the effect to develop, and that is where the difficulty will probably come in, but even an instantaneous effect is proportional to the incident energy. If one takes certain data which are now available one can prove that with selenium one can do certain very wonderful things. The calculations show that one ought to be able to discover stars certainly three magnitudes lower than those visible to the naked eye. The usual limit is about the sixth magnitude for naked eye vision, a sixth magnitude star giving 3 millimicrolux, equal to 3×10^{-9} metre-candles, so that with selenium one ought to have the ninth magnitude visible, and selenium will keep this

start over the eye, whatever the optical contrivances one may use. If, for instance, we have a telescope which discovers the fourteenth magnitude, selenium with the same telescope ought to reveal the seventeenth magnitude. This computation relies not upon the total effect, but upon the instantaneous effect. With these very feeble currents, such things as making a star record its passage on a chronograph or even making it ring a bell in its passage have been accomplished. I made the star Aldebaran do both these things. That is quite a simple thing to do, considering what very delicate relays are now at our disposal. I have taken it for granted that the lowest current which we use in such experiments is 10^{-11} amp. One can go lower than that, but other methods to be effective must have a certain duration of exposure. I show on the lantern screen the arrangement for determining the effect of faint light on selenium.

ACTION OF X-RAYS.

Now I should like to say something about the action of X-rays on selenium. This, I believe, was discovered by Perreau (*Comptes Rendus*, 129, 1899, p. 956), at a time when there was great research in all manner of directions in the field of X-rays. Perreau found, and others found also, that although the action was similar to the effect of light, there was one very important difference, namely, that the recovery in the case of X-rays was very much more slow than in the case of light. Such a result on the ionization view is just what we should expect. The Röntgen rays have a much greater penetrative power than ordinary light, and whatever ions are produced will be further apart than if confined to the narrow surface layer penetrated by light. It is natural to suppose that the Röntgen ray ions should be slower in finding each other. I know that some members present have distinguished themselves in following up the question of dosage of X-rays as measured by selenium. I need only mention in this connection Furstenau's dosage apparatus, which has been largely experimented with in London. I am not speaking on this part of my subject with any confidence, as my experiments have been very limited, but I should be very glad to make a temporary partner of any member who is working along these lines, and to place any selenium tablets or cells at his disposal for the purpose.

PHOTOMETRY.

I have now to deal with some applications. One of the first proposed, as one would expect, was to the measurement of light, or selenium photometry—the measurement of the brightness of light sources by means of selenium. That was a very few years after the light action was discovered, and was carried out by Rolls, Siemens, Poliakoff and Presser. The difficulty is the time necessary for recovery. That is a distinct difficulty in the way of selenium photometry. One must, as in the case of the eye, use comparative methods, and compare one source with the other, which can be done very successfully by rotation—rotating the selenium cell and finding whether there is any dissymmetry in the variation in passing from one source to the other. But the work can be done much more successfully by other optical systems like those which give the gradual transition; that has been worked out very ingeniously, but it should always be remembered that selenium is to some extent colour-blind. There is a strong reaction or resonance in the extreme visible red. The maximum is at about the line C, and that line divides the action of the energy of the spectrum into two equal portions. On the more refrangible side of this line one gets a certain amount of action, which is the same as the action on the less refrangible side. There is some effect—a very slight effect—in the ultra-violet, so that one can actually discover a very large range of the spectrum right away from the infra-red down to the ultra-violet.

OTHER APPLICATIONS.

Another proposed application of selenium is the working of automatic shutters in cameras. If this were practicable we should never be troubled about exposure, selenium acting as a perfect control, but while this is theoretically

possible, I do not think the advantages gained would outweigh the trouble of introducing relays.

Another application of selenium is in multiplex telegraphy. Let us suppose that we are exposing upon a number of selenium cells rapid flashes of light of different frequencies by means of a siren disc, one set of flashes being at the rate of 360 per second, another at 240, and others again at different frequencies, thereby making a musical scale. This will be transmitted to the other end, and then, by the application of suitable methods one may be able to analyse this superimposed message, picking out all the different notes through the telephone by means of tuning forks. In this way it would be possible to send twelve different sets of Morse signals along the same wire. At the receiving station twelve tuning forks would resound each to its own note, and twelve operators could receive these twelve different sets of notes at the same time. There again I cannot say how far this might be carried out practically, though a certain degree of success was obtained along these lines by Mercadier.

A very interesting application of selenium relates to the recording and subsequent reproduction of sounds. I show a lantern view in which there appear on a cinematograph film traces of successive exposures to a speaking arc—an arc which was either singing or speaking—and which therefore showed rapid fluctuations of sound corresponding to the nature of the sound waves which impinge upon it. These spaced images represent the successive flashes of the speaking arc, and by this means one arrives at a complete record of the sound. If this film be run rapidly through a cinematograph apparatus and the light be concentrated upon selenium we may obtain an exact reproduction of the speech, which I believe is very pure and perfect. The mechanism—the so-called photographophone of Ruhmer—has a speed of three metres per minute, and has been adopted in Italy for the reproduction of sounds in synchronism with the cinematograph reproduction of action, so that musical sounds may be rendered exactly concurrent with the gestures and facial movements of operatic singers as photographically recorded.

Then we have the interesting application of selenium to phototelegraphy, or the transmission of pictures along a wire. That was done successfully some years ago by Shelford Bidwell, and was developed to its fullest extent by Korn, who transmitted pictures by dividing them into strips and sending each strip to the receiving apparatus at the other end. Selenium, however, has been displaced in this work by another method, that of swelled gelatine, so that we may regard the use of selenium in phototelegraphy as merely a stepping stone.

I must just refer to the fascinating problem of television. It is one of the problems which certainly, I think, will be solved in the near future, or at all events in a future not very distant. Briefly put, it is the problem of seeing along a wire, and it follows, of course, that if we can transmit pictures fast enough along a wire we shall be able to see the images ultimately. But we are still some distance from that attainment, and there are great practical difficulties in the way. I think it was a Pole—Szczepanik—in 1897 who proposed a very ingenious method, and it was only some minor detail which turned out to be an absolute bar to his success. The principle is to make the selenium cell transmit the image, which is then recombined in the form of parallel lines which succeed each other so rapidly that the eye loses all sense of any intermission, just as it does in the case of the cinematograph.

Another promising application of selenium is to the automatic lighting of lighthouses and lightbuoys, which has been tried to some extent, but of which I have not been able to get any further particulars. The General Electric Company has, I believe, introduced a method of regulating switches on two lighting circuits by means of selenium, using lamps on each circuit to test the equality of the light ; if the light should show inequality the selenium is made to work a relay acting as a regulating device. I have on the table a little lighthouse which can be extinguished by exposing a lamp (representing the rising sun) in its vicinity. I

have also here the largest selenium cell ever constructed—a foot square—and I show the direct action of an electric lamp, using no relay. It consists of about fifty small cells in parallel with each other and in series with a half-watt lamp on a 200-volt supply circuit. You can see the half-watt lamp shining out as I illuminate the selenium.

Before I leave these miscellaneous applications I might mention that an American of the name of Bolton brought out in 1902 a method of copying loom card patterns in which selenium was employed. A very curious application has been also proposed, namely, that cigars and coffee beans should be sorted automatically according to their colour. The idea was that they could be run along a groove, and according to the brightness of the light reflected from them due to their variations of colour, they could be switched into one groove or another, and thus assorted on the basis of their reflecting power.

THE PHOTOPHONE.

Now I come to the last part of my lecture which deals entirely with the effects of intermittent light. I must speak first of the photophone, or wireless selenium telephony, which was invented by Graham Bell, and constitutes quite as great an invention as his telephone. I can show you a lantern view of an apparatus which has been used for showing the action of intermittent light on selenium. It consists of a disc with openings which is kept revolving at a rapid rate, producing flashes of light many hundreds of times per second. Selenium is capable of following the variations of light with great rapidity, and one gets these notes reproduced. As the disc is rotated more rapidly the note rises. The next view shows the general arrangement of Bell's photophone. The speaking tube arrangement ends in a diaphragm which has thin silvered glass on the upper surface. This diaphragm is made concave and convex alternately as the light waves impinge upon it, and the beam is transmitted to a distance where there is a mirror. The effect of all this arrangement is that the intermittent light impinging upon the selenium sets up a sound in the telephone. There is another device which shows this effect, namely, the acetylene telephone which has been developed to some extent in Holland, and of this arrangement also I show a view. It was greatly improved by the discovery of the speaking arc, and I show on the screen the arrangement adopted by Mr. Duddell for his arc, which very perceptibly resonates to any sounds impressed upon the microphone. The photophone has been used very successfully indeed for the transmission of speech over considerable distances. Some experiments made on the Wann See, near Berlin, were, I believe, rewarded with success, the maximum range being about seven kilometres (five miles). I do not suppose that the speech was very satisfactory at that distance, but at all events one has here a very promising and very important application of selenium.

THE OPTOPHONE.

I come now to the last apparatus I have to describe, namely, my own optophone, the object of which is to enable sightless persons to read ordinary type by ear. The principle adopted in the first type of optophone devised in 1912 (*Physikalische Zeitschrift*, 13, 1912, pp. 942-3) was to have a Wheatstone bridge arrangement into the two arms of which two selenium tablets were placed, and a galvanometer current interrupted by a clockwork motor was sent through a telephone. The effect of this arrangement was that it could be so tuned that any light impinging upon one of the tablets produced a sound in the telephone, governed, of course, by the interruptions due to the clockwork. One received as it were the sound effect of the illumination, and it might be said that one "heard the light." The disadvantage of this arrangement was the shifting of the zero. When exposing selenium one does not get the original conditions back instantaneously after cutting off the exposure. This disadvantage was eliminated in the "reading optophone" I subsequently constructed (*Electrician*, 72, p. 102, 1913), which enabled a person to read transparent type, provided that the letters were at least one inch

in height. I used a revolving disc perforated like a siren disc, and behind that a tubular lamp, and the intermittent light of various musical frequencies produced an audible telephone current. By using eight such frequencies emitted by dots placed in a row it was found possible to read letters by their characteristic sounds. The apparatus was more or less of a curiosity and had little utility, but nevertheless one could read letters quite easily if these were made transparent, being either photographed as transparencies or cut out in some opaque substance. I showed the instrument at the meeting of the British Association in Birmingham in 1913.

In order to make the instrument a useful one it was necessary to adapt it for the purpose of using type of the ordinary size, and to use the light on the selenium after it had undergone diffused reflection by the printed surface, and as a consequence the sensitiveness of the telephone arrangement had to be greatly increased. The ultimate apparatus is the type-reading optophone. Here again a siren disc is illuminated by a lamp. I now use a half-watt lamp edgewise, and throw a line image upon a radius of the disc. The disc is moved by a clockwork motor and the image of the line of luminous dots is made to converge upon a small aperture in a slab of some kind of material above which one slides the letterpress face downwards. The selenium tablet is exposed to the light diffusely reflected from the type and produces the corresponding sounds in the telephone receiver. The telephone is highly sensitive—responding to 1/15th of a microampère. That is really the whole principle of the instrument which was shown before the Royal Society in June, 1914. (Proc. Roy. Soc., A, 90, 1914, 373).

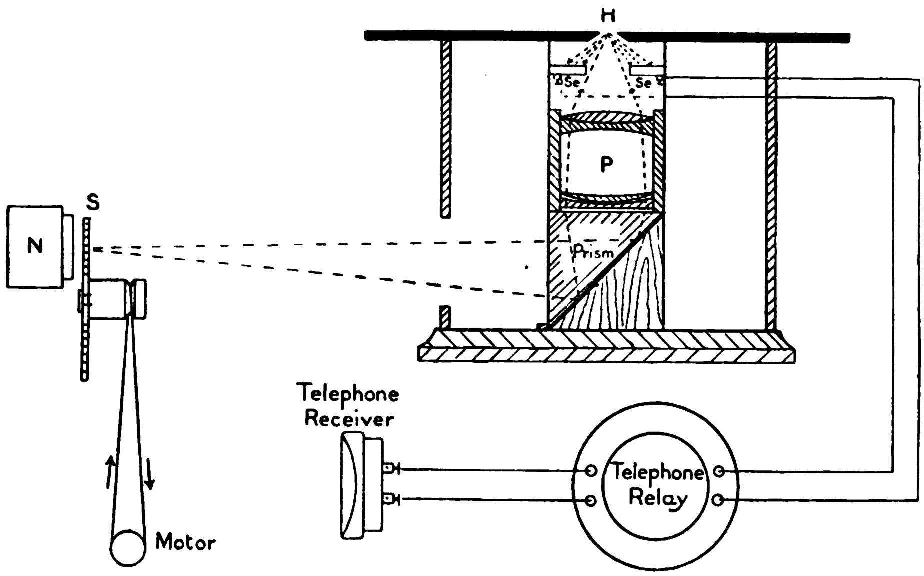


Fig. 3.

Further experiments were deferred because of the stoppage in the supply of the Nernst lamps I used originally, but the new half-watt lamp enabled me to continue the work and improve the articulation.

The sounds heard in the receiver are characteristic of each letter and depend on the letter's shape. The maximum sound consisting of all the notes at once is heard in the telephone when the paper exposed is white and there is silence when it is black. The small line of dots illuminates each letter in turn as the paper is passed along the slab in the direction of the printed line. With practice the reader can learn to pick up the sound of each letter with sufficient rapidity for the sentences to be

intelligible. One cannot, of course, expect to get proficient in a few hours, but the listener soon learns to recognise the distinct difference in tone between any two letters. One has simply to learn the alphabet in this new sound code and the system can be applied, given application on the part of the learner, to letterings other than Roman and Italic, the German or the Greek type, for instance. For demonstration purposes this evening I am using large separate printed letters, but a simple focussing device enables the operator to alter the length of the line of dots and so adjust it to the size of ordinary printed type, while the system of alignment on the reading slab enables the sequence of the letters to be perfectly maintained.

(Dr. Fournier d'Albe concluded by giving a demonstration of the automatic lighthouse; while the optophone was demonstrated to the members individually at the close of the meeting)

DISCUSSION.

Mr. A. A. CAMPBELL SWINTON said that he would like to express the Society's indebtedness to Dr. Fournier d'Albe for his very interesting address, both on its historical and its practical side. He did not suppose that many people had ever experimented with selenium cells; he (the speaker) had, and very tricky and trying things they were, and very difficult to get constant. He thought the author had been extraordinarily successful in such a little experiment, for instance, as that of the model lighthouse whose light was automatically extinguished by a lamp brought into its vicinity. He was anxious to hear the wonderful instrument for reading by sound.

Mr. T. THORNE BAKER said that the author had told them that the selenium apparatus for photo-telegraphy was superseded by other methods. He (the speaker) thought that everyone who had worked with photo-telegraphy would feel that had one persevered and gone ahead with it photo-telegraphy would never have died out as it had; it would probably be quite a useful thing to day. There would have been in all probability a reversion to the original apparatus of Korn in view of the fresh knowledge which had been acquired. He had found that if in Paris certain results were obtained, in London the results were different, and in Manchester again different, due, of course, to the influence of the atmosphere upon the selenium. The adjustment of selenium cells was a very delicate matter. If they were most carefully adjusted one day, the adjustment had to be made again just as carefully next day, even when the atmospheric conditions appeared constant. In some work he was engaged upon now, he was trying to use selenium in connection with X-ray measurements, and he found that the only way to get any constancy was to have the selenium cell kept from the atmosphere by immersion in a suitable oil, and always to work at a constant temperature, as near to freezing point as possible.

NOTES.

In view of the interest that attaches to the atomic weight of lead, careful analyses have been made by T. W. Richards and C. Wandsworth, with the following results :...

Lead from	Australian carnotite	206·342
,, ,,	American carnotite	207·004
,, ,,	Norwegian broggerite	206·122
,, ,,	Norwegian cleveite	206·084

The Australian mineral is known to have contained galena, which may account for the low figure due to the common lead thus introduced.

Reviewing the field of Radioactivity in the annual report on the Progress of Chemistry for 1916, Prof. Soddy states that researches upon artificial transmutation have all given negative results. The supposed production of helium and neon in vacuum tubes has not stood the test of careful experiment, neither does there appear to be any confirmation of the transformation of copper into lithium that was reported a few years ago.

Experiments carried out by Sir Ernest Rutherford, J. Barnes and H. Richardson with a Coolidge tube show that the penetrating power in aluminium, of X-rays reaches a maximum at 143,000 volts, and no sensible increase was observed when the voltage was raised to 175,000.

The maximum value of the absorption coefficient $\mu\,(\mathrm{cm})^{-1}$ in Al. is 0·39. The value of μ for the penetrating rays of Radium C is 0·115. The conclusion is reached that under laboratory conditions it appears very improbable that we can obtain X-rays as penetrating as the gamma rays from Radium C.

WE have received "Endocrinology," The Bulletin of the Association for the Study of the Internal Secretions, Henry R. Harrower, M.D., Glendale, California (Secretary).

We hope to give some notes on the contents of this new medical journal in our next issue.

ABSTRACTS.

The following are selected from the current numbers of "SCIENCE ABSTRACTS" as likely to be of special interest to members of the Society, and are published by permission of the Editors of that Journal.

170. *Chemically Active Modification of Hydrogen produced by Alpha-rays.* W. DUANE and G. L. WENDT. (Phys. Rev. 7. pp. 689-691, June, 1916. Abstract of paper read before the Am. Phys. Soc., April, 1916.)—A 5-cm.^{3} bulb of pure hydrogen was acted on by the α-radiation from 35 millicuries of radium emanation. A decrease in volume resulted.

A stream of hydrogen passed through a larger bulb and exposed to the α-rays liberated sulphuretted hydrogen when passed over sulphur, but this effect was reduced almost to nothing when the time elapsing after irradiation was increased to a minute.

The active hydrogen also attacks phosphorus with liberation of phosphine, and arsenic with liberation of arsine.

Neutral potassium permanganate solution was reduced to manganese dioxide, but indigo carmine and methyl violet were not reduced.

Exposure to liquid air after ionization removed the activity. T. M. L.

1180. *Mercury-vapour Pump.* H. B. WILLIAMS. (Phys. Rev. 7, pp. 583-584, May, 1916. Abstract of paper read before the Am. Phys. Soc.)—Describes a very simple form of pump which is much more rapid in action than the Gaede diffusion pump, and which seems to be equally effective in producing extremely low pressures. The vapour passes through a constriction connected to the vessel to be exhausted. Within the connecting side tube is a small Hopkins condenser, whose cooling effect, aided by that of the external air, condenses any vapour which may enter before it has penetrated far. Diffusion takes place through the annular space between the condenser and outer side tube. This space is 2 mm. wide and has an area of about 1 cm.^{2}. A larger Hopkins condenser above condenses the main stream of vapour, and the auxiliary pump is connected to it near the top. By arranging to have the diffusion take place at a constriction in the main vapour-flow tube, advantage is taken of the Bernouilli-effect. It is thus made possible to have the vapour pass the diffusion-point rapidly without reaching a lateral pressure so high as to cause it to pass far into the side tube. A lip projecting from the side tube into the main flow tube hinders the direct passage of vapour into the side tube. The eddies in the vapour stream which this obstruction produces probably hasten diffusion. As the gas which diffuses into the stream of vapour is rapidly carried to the upper condensation chamber, the usually slow process of diffusion becomes very rapid. The auxiliary pump should produce a vacuum of something like 0·1 mm. of mercury; but the pump will operate with a pre-vacuum of 0·25 mm., though its action is then much slower. Two pumps in series operate rapidly with a fore-vacuum of 0·25 mm. The mercury may be heated with a small open flame, or preferably by means of a small electric oven. Effective action does not depend so critically upon precise regulation of temperature as in the Gaede type. The pump is rapid in action. A single pump with a May-Nelson oscillating ring pump as auxiliary exhausted a two-litre bulb with large Al electrodes from atmospheric pressure to a point where the alternative spark-gap measured 18 cm. in 7 minutes. Two vapour pumps in series connected directly to a McLeod gauge reduced the pressure from approximately 0·25 mm. to $4 + 10^{-6}$ mm. in 4 minutes. A short time later the pressure was too low to be measured. A. W.

1351. *Absorption Coefficients of Soft X-rays.* C. D. MILLER. (Phys. Rev. 8. pp. 309-343, Oct., 1916.)—The object of the experiments described was to study the nature of X-rays produced at low potentials. For this purpose a specially constructed X-ray tube was employed, the very soft radiation being allowed to escape through a window (6 cm.^{2} in area) of Al leaf (0·000675 cm. thick). This Al leaf was supported by a phosphor-bronze gauze (180 meshes per inch), and under such conditions was found to be strong enough to bear the outside air pressure without serious leak. The tube was permanently connected to the exhaust pump, the pressure in the tube ranging from 10^{-4} and 10^{-5} mm. of Hg. The X-rays emerging through the window were detected and measured by means of an ordinary gold-leaf electroscope, the bottom of which was covered with a sheet of Al leaf ($\frac{1}{10}$th the thickness of that covering the window of the tube).

The sheets of material used for absorbing the X-rays were of gelatine, celluloid, and aluminium. The results obtained are collected in the following table:—

Potential.	μ/ρ in Al.	μ/ρ in Celluloid.	μ/ρ in Gelatine.	(μ/ρ) Cell / (μ/ρ) Al.	(μ/ρ) Gel / (μ/ρ) Al.	(μ/ρ) Gel. / (μ/ρ) Cell.
2500	(1930)	—	312	—	—	—
3000	(1190)	—	193	—	—	—
3460	(778)	—	126	—	—	—
3930	(474)	81·0	76·2	—	—	0·940
4420	(351)	60·0	56·6	—	—	0·943
4880	(249)	42·5	38·7	—	—	0·910
5870	149	25·6	25·8	0·172	0·173	1·01
6780	101	—	—	—	—	—
7700	71·7	12·3	11·4	0·172	0·159	0·927
8860	47·3	—	—	—	—	—
9970	34·7	5·90	5·39	0·170	0·155	0·914
Mean				0·171	0·162	0·941

Plotting log V and log (μ/ρ) it is shown that the points for 4880 to 9970 volts, inclusive, lie remarkable close to a straight line.

The results give $\mu/\rho.\ V^{2\cdot77} = 4\cdot24 \times 10^{11}$, which, combined with the quantum relationship $Ve = h\nu$, becomes $\mu/\rho = 19\cdot4\,\lambda^{2\cdot77}$. Here λ is in Å.U., and μ/ρ is for Al. This result is in good agreement with that found by Siegbahn [Abs. 105½ (1915)], who obtained $\mu/\rho = 19\lambda^{2\cdot78}$, using the absorption coefficients of the various characteristic radiations and the wave-lengths obtained by Moseley.

Curves showing how μ/ρ varies with the thickness of Al traversed are given. The author finds the relation $\rho d = 4\cdot4/(\mu/\rho)$ to hold good (ρd = mass per cm.^{2} of Al through which the rays have passed). A. B. W.

EXTRACTS FROM THE TECHNOLOGIC PAPERS OF THE BUREAU OF STANDARDS.

The following are summaries of scientific papers published by the BUREAU OF STANDARDS, WASHINGTON.

The Editor will be pleased to send the originals of any of these papers to members of The Röntgen Society upon application.

"SENSITIVITY AND MAGNETIC SHIELDING TESTS OF A THOMSON GALVANOMETER FOR USE IN RADIOMETRY."

THIS paper describes an investigation made to improve the sensitivity and design of a specialized galvanometer for use in radiometry. By using a lighter suspension in a vacuum, the sensitivity was increased tenfold. The results will be of great value in the study of stellar radiation, since the recent advances in this field called for the increased sensitivity which has been now obtained. The paper gives details as to construction and results of tests, and the paper concludes with the following summary.

Numerical data are given relating to the force exerted by coils having various resistances. A simple coil is described, wound with a single size of wire (No. 28) which was found to be very efficient.

A 9-ohm coil (see test on the 8·6-ohm coil) is described which is very efficient and is well adapted to be used with the bismuth-silver thermopiles previously described.

A comparison is made of various astatic magnet systems and data are given showing the importance of using small mirrors in order to increase the sensitivity.

Experiments are described on shielding the galvanometer needle from external magnetic disturbances. The galvanometer coils are mounted in cavities cut into blocks of Swedish iron, which reduce the air space and act as a magnetic shield. This elimination of convection currents greatly improves the steadiness of the needle system. Various shields are described, consisting of laminated cylinders made from transformer iron and solid cylindrical shells cut from wrought-iron gas pipe. By embedding the galvanometer coils in blocks of Swedish iron which are surrounded by cylindrical shells of transformer iron and of wrought iron, the effect of external magnetic perturbations upon the astatic needle system is easily reduced to 1/2000 of its original value.

Experiments on a vacuum galvanometer are described, in which a sensitivity was attained which is more than tenfold that used in the writer's previous work on stellar radiation.

Price to Non-Members,
4s. net; 16s. per ann.

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RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Institution of Electrical Engineers on Tuesday, March 6th, 1917, Dr. G. B. Batten in the chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society:—Mr. H. D. GEORGE, Lieut. R. CASMAN, Dr. R. OSBORN SMYTH, Mr. J. C. WILSON, Mr. HENRY T. P. GEE.

NOMINATIONS.

ELIZABETH SIDNEY SEMMENS, B.Sc. Lond., Science Teacher and Lecturer, West Grove, Sandgate.

Proposed by Sir JAMES MACKENZIE DAVIDSON.
Seconded by AFLRED W. PORTER.

ARTHUR BURROWS, M.D., Radiologist, Radium Department, Royal Infirmary, Manchester.

Proposed by Dr. BARCLAY.
Seconded by R. KNOX.

A paper was read on " Intensifier Screens: their Physical Properties and Practical Applications," by T. Thorne Baker, F.C.S., A.M.I.E.E.

THE PHYSICAL PROPERTIES OF INTENSIFYING SCREENS.

By T. THORNE BAKER, F.C.S., A.M.I.E.E.

The intensifier screen has become such an essential part of every X-ray equipment, and so many hospital operators have to deal with these screens, and in many cases voluntary, but inexperienced helpers develop the plates exposed with them, that some general considerations of their physical properties may prove of value at the present time.

Only recently I came across a case where a lady volunteer in the dark-room of a military hospital attempted to develop the intensifier screen instead of the plate, and was much distressed because no image appeared. This is, of course, a most exceptional case, but the fact remains that, whereas the greatest discrimination should be exercised throughout when using intensifier screens, they are very frequently handled without much thought, and the result is that many imperfections and shortcomings have been laid to their charge which in reality do not exist. There are also several points in connection with their behaviour on which differences of opinion exist, and I hope on the present occasion to be able to clear up some of these points.

It is common knowledge that an intensifier screen consists of a thin card base coated with the crystalline form of calcium tungstate, Ca WO_4, which occurs naturally as Scheelite, or can be produced from the amorphous, precipitated tungstate of lime by suitable chemical treatment. The layer of tungstate which forms the sensitive coating does not completely absorb the X-rays; only a proportion of the incident rays are absorbed, as we shall see later on, but the absorbed rays excite fluorescence in the crystals, and hence a visible image is formed, just as it is on a platinocyanide or other fluorescent screen. The visibility of the image is low, however, because the colour of the fluorescent rays is blue-violet; but these rays have an

intensely high photo-actinic value, so that the blue-violet image produced in the screen affects the photographic plate far more quickly than the X-rays alone would do; the result is the well-known decrease in exposure, so that an exposure of about one-tenth to one-twenty-fifth of the normal only needs to be given.

By suitable chemical treatment the tungstate may be made to give a more violet spectrum on excitation by the X-rays, or it may be made to give a bluer spectrum. If we photograph the spectrum of white light on an ordinary

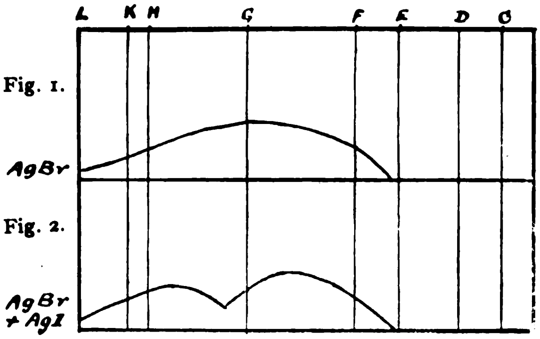


Fig. 1.

Fig. 2.

plate, and measure the density of the negative photometrically for various wave-lengths, and plot a curve showing the relation between wave-length and density, we shall find that in general the maximum sensitiveness of the plate lies between the G and F Fraunhofer lines (see Fig. 1); by making a plate emulsion with a mixture of silver bromide and silver iodide—prepared separately, not emulsified together—we can produce a plate with two maxima of sensitiveness (see Fig. 2), one at H $\frac{1}{2}$ G, and one at G $\frac{1}{2}$ F approximately. Such a plate, if obtainable, would undoubtedly be ideal for intensifier screen work, as the spectrum of the fluorescent rays produced in the various makes of screens appears from spectro-photometric measurements to lie around these two regions.

Obviously the ideal intensifier screen and plate combination would be that in which the spectrum of the screen fluorescence coincided with the region of maximum of sensitiveness to the spectrum of the plate employed, and though there is a happy tendency in modern screens and plates for this to be realized, it is by no means definitely accomplished.

Each substance which can be excited to fluorescence by means of the rays gives a different spectrum; excitable calcium sulphide gives a maximum between G and F, zinc sulphide a maximum of still lower refrangibility, platino-cyanides of different metals fluoresce yellow, green and red in different cases, and so on, and if the after-effect or persistence of fluoresence could be eliminated from certain of these substances, there is little doubt that a very much greater speed could be obtained in photographic work with a screen, on account of the ease with which we can to-day sensitize a photographic plate for any particular region of the spectrum. Many of the fluorescin, cyanin and iso-cyanin derivatives impart distinct maxima of sensitiveness to a photographic emulsion, and by a suitable combination the plate could be sensitized to complement more or less exactly the fluorescence of any of these substances.

Our business to-night, however, is with the intensifier screen as we find it to-day, and the questions I should like to deal with are, briefly, exposure, choice of plate, method of development, and control of the character of the image.

Before dealing with exposure, I will ask your indulgence for a few moments to describe a

Fall in Resistance of Selenium Cell.

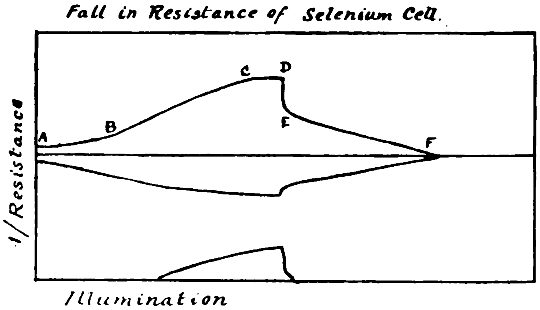


Fig. 3.

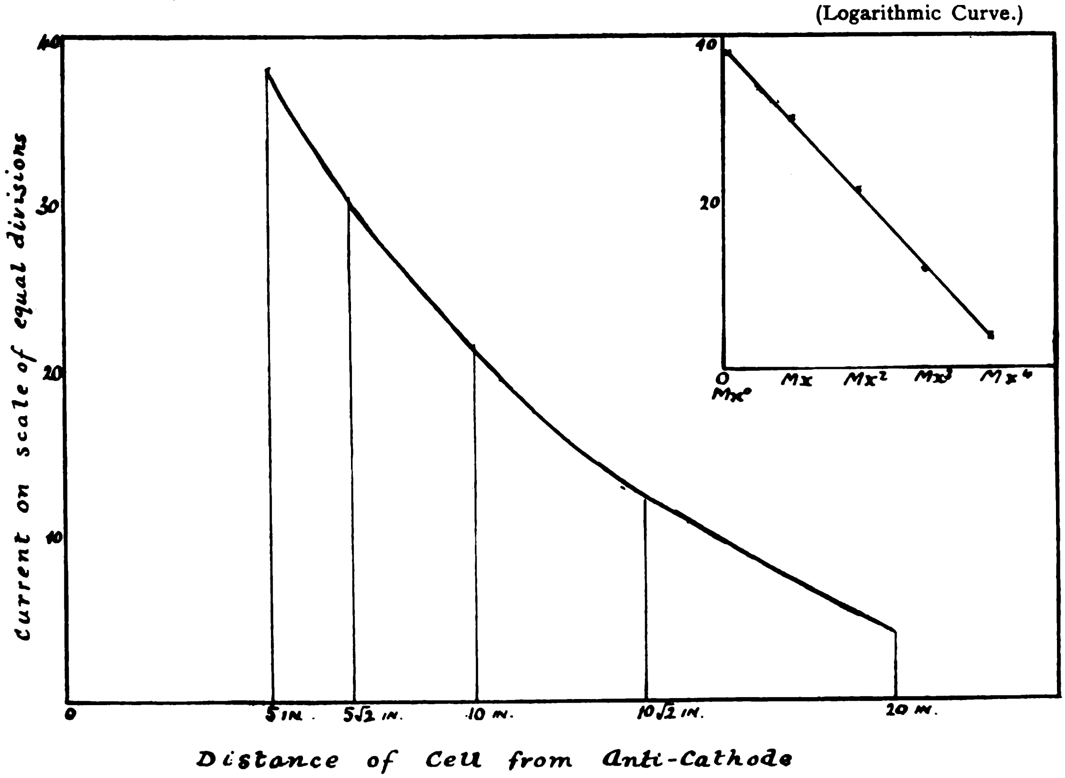
simple form of laboratory actinometer which has proved of some value in arriving at a few of the purely comparative measurements involved. This is a selenium cell apparatus, and I am fully aware that at the present time it is not regarded with much favour. I had the

opportunity of studying many of the vagaries of selenium in the telegraphy of photographs, and as you may remember the one apparatus depending on selenium which proved of use commercially was that invented by Prof. Arthur Korn, of Munich, who, by the way, was for many years a colleague of Prof. Röntgen. Two or three years' work trying to harness selenium, under Prof. Korn's able guidance, coupled with some further work in connection with high-speed wireless telegraphy, showed many things, and to sum up briefly, there is evidence that selenium can be used with a considerable amount of success if the cell is selected having a very high resistance, (500,000 to 800,000 ohms), and a very low inertia, and provided the cell be always used at a constant temperature, with atmospheric influences eliminated.

The diagram (Fig. 3) shows the general character of the resistance/illumination of a typical good selenium cell. It will be seen that up to a certain point, increase in the illumination (or ionization by X-rays), only causes a slight reduction in the resistance of the cell; this part is represented by A to B, and corresponds to the inertia of the cell; after the point B is reached, the resistance becomes lowered rapidly as far as a point C, with increase in illumination or ionization; after C, the curve tails off again. When the illumination or rays are cut off, the resistance increases suddenly to a point E, and then gradually tails off along the portion of the curve represented by EF. Now if we work only on the portion BC, we shall not only get a fairly accurate means of measurement of the X-rays, which is well in accordance with the photographic power of the rays, but we shall also to a great extent eliminate the inertia of the cell. The latter can be effected by having the cell constantly illuminated with a small source of light, properly standardized,

CURVE SHOWING RELATION BETWEEN RESISTANCE OF SELENIUM CELL AND INTENSITY OF X-RAY BEAM.

(Logarithmic Curve.)



or by a suitable ionizing influence, until the current registered by the galvanometer is at B. Excitation by the X-rays then rapidly increases the galvanometer readings up to C, and between these two points we can construct an arbitrary scale which is of real value in X-ray measurement for photographic purposes. The cell itself is contained within a glass vacuum cell, or a cell filled with oil, kept always at 15°C., and a 1 mm. thick sheet of aluminium is placed in front of it to absorb the very soft rays. I hope in a later paper to be allowed to deal fully with this instrument, as there are reasons for believing that it will satisfactorily aid the pastille in dosage measurement. An instrument of the form described has been used in making some of the measurements or in checking other measurements in the work described.

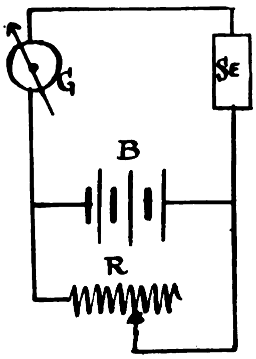


Fig. 5—Diagram showing connections of Selium Cell and Microammeter (G).

Exposure is the first point on which complaints as to the performance of an intensifier screen are so frequently based, *viz.*,

(i.) lack of contrast in the negative,

(ii.) diffusion of the image.

Both these complaints are, I hope to be able to show, groundless.

It is a common source of complaint that photographs taken with the screen are weak, *i.e.*, that they lack contrast. An ordinary daylight photograph will be weak or flat if over-exposed, as is well known, and practically all failures with intensifier screens due to lack of vigour or contrast are caused through over-exposure. If we expose successive strips of a photographic plate to white light for periods increasing by a geometrical ratio, and measure the densities of the developed strips (*i.e.*, the logarithms of the opacities) by means of a photometer, and plot them against the corresponding exposures, we get a curve showing the gradation of the negative. In the diagram now on the screen we see

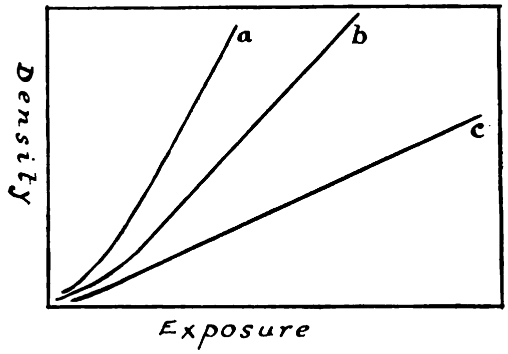


Fig. 6.

three such curves roughly indicated; *a* represents a soft or flat negative, such as would be obtained by over-exposure, or by a plate developed with a developer containing too much alkali; *b* represents a plate one would probably describe as correctly exposed and developed; *c* represents a plate under-exposed and given prolonged development, which is consequently harsh or too "contrasty." The angles *a*, *b* and *c* make with the horizontal give relative measures of the hardness or degree of contrast of the negatives, *i.e.*, the steepness of the gradation. Measurements made on this basis by the Hurter & Driffield system are employed in all photographic plate investigations, and are of immense value. Now suppose we substitute the X-rays for the purpose of exposure, and expose successive portions of the plate through 1, 2, 3, 4, etc., thicknesses of aluminium, or plate glass, and prepare similar curves. Let us assume that curve *b* represents the gradation of a correctly exposed and developed X-ray plate. We can get at all times equally good gradation if the plate be exposed through an intensifier screen, always provided

that exposure be correct and development normal. Many radiographers claim that this is not the case, but repeated tests made under the most varied conditions show that this is the case.

A typical example is shown in the slide now on the screen. Here A represents a plate exposed for twenty seconds to the X-rays, B a plate

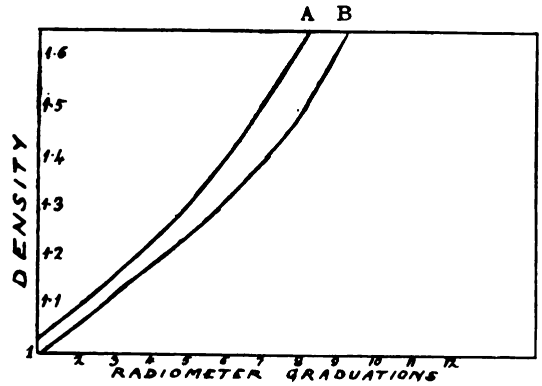


Fig. 7.

exposed for one second through a Sunic screen, which reduced exposure by 95 per cent. Both plates were developed with the same solution, but the plate exposed through the screen was given longer development. This at once implies unequal treatment, but a little consideration will show that this is always necessary.

The X-rays, when used without a screen, penetrate and expose the entire film of the plate, and on development, as soon as the film has absorbed the developer throughout, development takes place throughout its entire thickness, *i.e.*, every "layer" of silver bromide particles are attacked nearly simultaneously by the reducing agent. When an intensifier screen is used, the exposure is chiefly superficial, the blue-violet rays responsible for the image are absorbed by the uppermost layers of silver bromide, development starts at the surface of the film, and has to work slowly downwards. If a plate exposed through a screen develops as quickly as a plate exposed without a screen, *it* may be taken for granted that the former *will* have been over-exposed. It is very important to bear this in mind. The development factor may be said to be different, *i.e.*, the ratio between the time taken for the first appearance of the image and the time required for complete development is greater. Factorial development, if systematically applied to X-ray photography, would greatly facilitate X-ray work and render the results far more uniform. In a paper I had the privilege of reading before this Society over ten years ago I endeavoured to point out how little the best methods of the photographer had been applied to X-ray work, and despite the enormous progress that has been made during these ten years very much the same may be said from a purely photographic standpoint to-day.

A number of different makes of intensifier screen are in use, and considerable improvement has been effected during the last three or four years; it thus happens that there is not one uniform grade of screen in general use; some screens are faster than others, some much more granular than others; hence as a broad rule it may be said that each time a new intensifier screen is brought into use it should be carefully tested for speed, and these tests should be carried out with the plates which are to be employed in practice. There is, and there will be likely, a great lack of standardization both in intensifier screens and in X-ray or screen plates; we are only on the fringe of the physical chemistry of intensifier screens (and I think that before many months are past an increase of two or three hundred per cent. in their speed is certain). The spectrum-sensitiveness of the different brands of X-ray plate and screen plate differs considerably; many radiographers use ordinary plates for screen work, and the spectrum-sensitiveness of different brands of ordinary plates also differs. Hence we cannot say that a certain intensifier screen will reduce exposure by, say, 95 per cent. It may do so with A's plate, whereas with B's brand of plate it may only reduce exposure by 92½ per cent. This means a variation of as much as fifty per cent. in the actual exposure with the screen!

It is impossible to lay down any definite law, but it may be said as a general rule that if a correctly exposed X-ray plate require seven

minutes for development, the same plate exposed through the screen will require ten to fourteen minutes' development. In testing a screen we must therefore, by the method of trial and error, obtain two plates, one exposed without the screen for x seconds, the other exposed with the screen for y seconds, which, developed for 7 and 10-14 minutes respectively, produce identical images. x divided by y gives the number of times by which exposure is reduced when reducing the screen for the given plate.

Another point on which emphasis may be laid is that there is not the same latitude when using a screen. In an exposure without it, if 5 seconds were correct, we could probably give 4 or 8 seconds and still get an equally good result. The same case, when using a screen reducing exposure to $\frac{1}{20}$th, would at least mean that the exposure, instead of being $\frac{1}{4}$ second, might be $\frac{1}{8}$th second or $\frac{3}{8}$ths—the amount of actual latitude would run into small fractions of a second. But with the superficial effect exerted by the screen on the plate, the latitude is diminished still further than this ratio suggests, and more care is therefore necessary. Correct exposure, coupled with perfect contact, between the screen and the plate are essential points in screen photography; over-exposure is unquestionably the chief cause of trouble, while the big reduction possible with modern intensifier screens is not always sufficiently realized.

It is perhaps touching on rather elementary ground to deal with the contact question, yet one has to deal with so many complaints as to diffuse image that it seems justifiable. I have got the most satisfactory and rapid results of any by actually coating an intensifier screen upon a dry plate, *i.e.*, using a dry plate as a substitute for the cardboard support ordinarily employed. In this case, of course, true optical contact is obtained, with a very great increase in speed and in sharpness of definition. Such a method of manufacture would obviously be impossible in practice, as it would mean every plate requiring its own individual screen.

There is a tendency in some casettes or exposures cases for the upper cover to bulge, in others a lack of spring pressure from the back; a good deal can be done by packing with very soft blotting paper. Unless very perfect contact be obtained between the sensitive surfaces of the screen and plate, considerable diffusion of image—usually in local patches—results, and what is more important also, a general lessening of exposure. It may be said without exaggeration that a screen pressed with intense pressure against the plate will reduce exposure easily by as much as 100 per cent. more than the same screen only in moderately good contact. This is a point which has come out prominently in making comparative tests of different intensifier screens of different thickness. The nearer then that we can get to optical contact the better.

In connection with the diffusion of the image we have to consider the grain of the intensifier screen. In the early days of these screens we were recommended to expose the screen through the plate, *i.e.*, have the glass side of the plate facing the anti-cathode, and the screen, sensitive surface uppermost, beneath the plate—this also in some recent text-books. The X-rays would have thus to pass through the glass and the silver bromide emulsion before reaching the screen. Any granular effect in the screen would thus be minimized and sharper detail would be obtained. Screens are obtainable to-day in which the grain is so fine that, practically speaking, it is not apparent in the negative, and this method is not therefore necessary if a suitable screen be employed.

An intensifier screen was cut into two parts and an X-ray plate cut into two pieces, and the two halves of the plate exposed side by side under a sheet of wire gauze; in the case of A the exposure was made through the plate, the screen being underneath; in the case of B the screen was uppermost and the plate underneath. The two plates were developed side by side for the same time. The densities in each case were measured, and the comparative negatives are seen in the slide shown on the screen. It will be seen that A is far less exposed than B, showing the advisability of having the

screen above the plate, sensitive side downwards, and not *vice versa.*

The form of calcium tungstate employed in preparing the screens is a crystalline one, and although, as is well known, by grinding or crushing crystals, to decrease their size, their fluorescing powers are minimized, the total value of the light per unit of area being lessened by dissipation, methods have been evolved whereby the size of the crystals can be controlled, with the result that the grain of the intensifier screen is practically no larger than the grain of the photographic plate. Secondary radiation is set up by the impact of the X-rays upon the crystals of calcium tungstate, and the diffusion thus caused gives rise to an apparent granularity in cases of over-exposure, and this granularity is, of course, greatly accentuated if contact is not perfect between the screen and the film of the plate, the effect varying as the square of the distance between them.

While on this subject it may be interesting to deal with the opacity of the intensifier screen. Energy must, of course, be absorbed by the calcium tungstate in order to produce fluorescence. It is recognised that the physical state of fluorescence increases the absorbing power up to a certain point, and this fact has to be borne in mind in attempting any measurements. In other words, a given screen may absorb a smaller proportion of the rays if excited by a weak beam of rays than it would if excited by a stronger beam, and it is conceivable that a limiting point may be reached after which a more powerful output from the tube would be valueless with a given screen. Nichols and Merritt found that if the intensity of the incident light is gradually increased, the absorption due to fluorescence increases to a constant value, and these results, based on observations made with visible light, are apparently applicable to substances fluorescing under the influence of X-rays.

A platinocyanide screen placed 5 in. from the anticathode, with 1 milliampère passing through a tube of 7 Benoist hardness, reduced the reading given by the selenium actinometer by 4 per cent. A Sunic intensifier screen in the same position reduced the reading by 35 per cent. A zinc silicate (Willemite) screen gave the same reading. It will be seen that the intensifier screen absorbed only 1/1·44 or roughly two-thirds of the incident rays. The remainder of the incident rays passes through the screen. This has a direct bearing on another vexed question, *viz.*, as to whether an X-ray plate or an ordinary plate is the better for screen work. If we use a plate which absorbs a great deal of the energy not already absorbed by the screen, it is reasonable to assume that the latent image after exposure will be due to (i.) the superficial exposure from the screen, plus (ii.) the exposure throughout the film due to the X-rays which have traversed the screen. The latter, *i.e.*, the silver bromide film, varies in its opacity to the X-rays considerably; the readings on the selenium actinometer with a well-known X-ray plate was 11, whereas the readings with a well-known make of screen plate and that of an ordinary plate were each 15.

The combined effect will therefore vary, and it cannot be definitely said that under all circumstances screen exposures are best made with one or the other. The great latitude of the X-ray plate, which is very heavily coated with silver bromide of a form peculiarly opaque to the rays, must always make it preferable for screen work on this particular ground. The grain, also, of ordinary plates is apt to be much coarser than that of a really good X-ray plate, especially of the faster varieties of the former, whereas the silver bromide in an X-ray plate has been precipitated in an excessively fine form in order to increase its opacity.

The busy routine work of a hospital forbids any serious attempt at control in development; results have to come out good almost automatically, and in the occasional case of a bad result, a fresh plate is exposed. This is unfortunate in the sense that the refined methods of the photographer cannot be brought into play to deal with abnormal exposures. The great variation with different developing agents may be seen from the fact that the factor for

Hydroquinone is 5,
Metol is 30,
Rodinal is 40, and so on.

The ratio of the time taken for the first appearance of the image to the time required for complete development remains the same whatever the temperature, but the temperature has a great effect on the time of development. Each developer has its own temperature coefficient, but the effect of one degree in temperature on all developers is affected by practically the same amount.

By taking into account these various factors, a degree of uniformity which should prove of great value might be attained, but the greater variant—the photographic value of the X-ray beam, would have to be under better control, such as it is with a Coolidge tube. I may say, however, that I have found that the selenium cell worked under the conditions described to conform admirably with the photo-chemical effect of the beam, and its use, combined with factorial development, usually gives a high degree of uniformity, such as is indispensable in the efficient testing of intensifier screens.

Generally speaking, although in the ordinary way the developing solutions employed for X-ray work are more concentrated than those used for ordinary photographic work, still higher concentration is advisable for screen work, coupled with rather more bromide. Thus in a combined developer made with hydroquinone and a metol substitute, the latter may be reduced in quantity and the hydroquinone increased. This will more readily give the contrast desired, while the extra concentration will make the developer work more rapidly, so that the operator does not have to differentiate very much between screen exposures and other ones.

A word may be said in conclusion in reference to the sustained image noticeable with certain screens. Careful tests show that the phosphorescent image which can be seen immediately after exposure, which remains for some time with certain makes of screen, is of little value in forming the latent image in the plate; in some cases, if the plate be left in contact with the screen for some time after exposure, the effect of the actual exposure can be slightly increased, but the increase is small in comparison with what would be obtained from a very small increase in the exposure to the X-rays. It is doubtful whether the spectrum of the phosphorescence is the same as the spectrum of the fluorescence; in fact, it is certainly of longer wave-length in some cases and of less photo-actinic value. Some workers make a point of leaving the plate in the exposure case for about half an hour after exposure, and it may be of interest to them to know that the end does not justify the means.

DISCUSSION.

Lt.-Col. ROBERT WILSON said: Generally in Canada, we do not use screens for bones and subjects of that kind, but for intestinal cases, in the rapid radiography of the pylorus and of the stomach itself: we pass a very heavy current through the tube and obtain with the screen practically instantaneous exposures. That certainly bears out the remarks of Mr. Thorne Baker that a short exposure with the large current gives a clear image. If we put forty or even up to seventy milliampères through the tube and give an exposure of one-tenth of a second, we get with the screen a perfectly clear-cut picture which does not show any grain. Nothing smaller than a 20-in. coil is any use in these cases. I have not had much experience with the screens in routine war practice, but in our base hospitals in England we are using the Snook apparatus, and employing screens for stomach work.

Dr. E. S. WORRALL: I listened with much pleasure to Mr. Baker's paper, and it reminded me of a very interesting address by Professor Jackson, of King's College, on the subject of phosphorescence and fluorescence which was given before this Society years ago. I remember, as I dare say others will, that he showed us on that occasion a very large number of interesting experiments—which all came off, by the way—and amongst other things he pointed out the greatly increased luminosity of these bodies due to warming them. I should like to ask Mr. Baker whether he has ever thought of

warming the plate and the screen before use.

Dr. R. W. A. SALMOND: I should like to ask Mr. Thorne Baker one question. Does he think it of any advantage to use two intensifying screens, one on either side of the plate, as is sometimes done? With the varying thicknesses of glass one meets with nowadays, it is possible that here we have an explanation of some of the lack of sharpness we find occasionally with screen plates. In a recent article by Threlkeld-Edwards, the well-known maker of screens in America, he states that he gets his best results by using a very heavily coated intensifying screen in conjunction with the film, passing the rays first through the film and then on to the intensifying screen. I have noticed that the fluorescence of the intensifying screen with an exposure of three milliampères for five seconds is longer than it is with an exposure of one milliampère for fifteen seconds, so that the duration of fluorescence is not altogether a question of the milliampère-second exposure.

Mr. W. E. SCHALL: I should like to ask Mr. Thorne Baker whether there is any great advantage in working with the rays passing first through the glass of the plate, then through the film and finally to the screen. Some years ago I made a number of experiments, trying the difference between exposing with the rays first passing through the screen and then on to the plate, and afterwards the other way round, first through the glass, then the film, and then the screen; and I found that the retardation due to the glass was so great that the effect of the screen was greatly reduced, but I found also when I used some Continental plates, either Lumière's or some others, that the effect was practically the same whether the rays passed first through the screen or first through the glass of the plate. Then I tried various makes of plates—Ilford and others—and my original observation was confirmed, which suggested that there must be some heavy element in the glass. It would be an advantage to have the screen under the plate, because, particularly when working with the tube above, a better contact would be possible between screen and plate, and if it could be brought home to the plate-makers, perhaps a glass which does not absorb the rays to the same extent might be used. With regard to Dr. Salmond's remark, in the early days it was customary to use two screens, but then a film was used, so that both screens were in very close contact with the sensitive part of the film. I think that if a screen were used on the glass side of the plate with the film on the other side, one would necessarily get blurring.

The CHAIRMAN: I should like to ask whether screens get less powerful with age or use. Somehow, it seems to me that they do, and if they do—can they be recovered again by exposure to light or any other device? Another observation I have made—possibly erroneous—is that accelerating screens do not work so well with a soft tube. One does not often want to use an accelerating screen with a soft tube, of course, except in the case of a bismuth meal, for if a soft tube is used in the ordinary way it is for a thin part of the body, and in that case an accelerating screen is hardly required. But I have not had such good results with soft as with hard tubes, so far as the accelerating screen is concerned. Then there is a practical point in connection with development. We all know that in the development of a plate used with an accelerating screen the image on the surface comes up quickly. Ought one to proceed with development until the back is darker than it was when one first looked at it? In the ordinary way one holds the plate up to the red light and stops the development when the outlines of the flesh—in the leg, for example—have disappeared. I have found that a very good rule with regard to ordinary X-ray plates that have not been used with accelerating screens, but I do not think that when the accelerating screen has been used it answers so well. Another point on which I should like to ask a question is: Is there any good way of cleaning a dirty accelerating screen?

Mr. T. THORNE BAKER, in replying to the questions, said: With regard to Dr. Worrall's remarks about the effect of warmth on the screen, there are certain forms of calcium tungstate which will fluoresce rather more

brightly in a warm atmosphere than in a cold, but I think that this is one of the cases where the end would not justify the means, because such a slight increase in the reduction of exposure would be so small compared with the primary reduction due to the screen. Dr. Salmond referred to the use of two intensifier screens, one on each side of the plate and film. If the screen on the film side is not very good, and absorbs a large proportion of the X-rays, the screen on the other side will not be very effective, but if one employs an ordinary crystalline screen on the top of the plate and has a semi-crystalline and very absorbent screen at the back of the plate, one can easily reduce the normal screen exposure by about 66 per cent., giving one-third of the exposure customary. But I do not think that any screen of that character is at present obtainable. A question has also been raised about the heavily coated screen and the effect of the ampèrage on the screen. That raises another point: a very thinly coated screen—that is to say, coated with a thin layer of calcium tungstate—will give a better result with soft than with hard rays, and therefore if one is making comparisons with screens one may get an entirely different set of results with a tube running soft from that which one gets with the same tube running hard. There is no question but that later on we shall adopt two standards of screen, one for installations of low power, and another for installations of high power. Mr. Schall, in speaking of the screen being exposed through the plate, was probably referring to a type of glass used by the French and called verascope glass—a very thin glass with a small co-efficient of absorption of the rays. The photographic emulsion of a good X-ray plate absorbs about 8 per cent. of the X-rays, and unsuitable glass may make it absorb up to 40 or 45 per cent. of the rays, so that it is evident the glass has more to do with the absorption of the rays than the emulsion itself. The effect of age on the screen resolves itself again into a question of the crystalline structure. Calcium tungstate can be prepared in so many degrees of "crystallineness"—if I may use the word—that it is difficult to make any very definite statement. If the crystalline structure is good there should be no sign of destruction with age. But there seems to be a definite tendency for the semi-crystalline particles of calcium tungstate to go back to the amorphous state, and thus a screen may lose speed under the action of the rays if used a good deal. As to the cleansing of intensifier screens, most of the modern screens are readily washable with water, if not, cleaning with benzol or alcohol, or with a piece of indiarubber removes most ordinary dirt. If one gets a screen splashed with developer, however, as the developer is so readily oxidized, no known method of purification will get out the stain produced.

A NEW SCREEN LOCALIZER.

By MAJOR STOWE.

This localizer has been designed to save time, an important matter in military hospitals when casualties are heavy. At the same time its accuracy, given good workmanship, is beyond question.

It consists of two small platforms, 3½ inches apart, fitted with accurately adjusted cross wires and sliding metal rings A, B, bi-sected by fine metal rods. The upper ring A carries a small fluorescent screen (Fig. 1).

In use the localizer is placed on a small wooden platform (Fig. 2) with a few holes bored in the middle of it. This platform, secured to the overhead gear of the couch, is lowered into contact with the patient's skin.

The position of the localizer is then adjusted by means of the vertical beam of rays until the shadows of the two sets of cross wires register exactly and the shadow of the foreign body is bisected in both directions by the intersection of them.

It is now evident that the intersection of the wires, the centre of the foreign body and the focal point on the anticathode are in correct vertical alignment.

The tube is now shifted one way or the other 10 centimetres or more according to the depth of the foreign body, more for one that is near the skin in order to get a satisfactory angle.

The upper ring is now shifted until its shadow encompasses the shadow of the foreign body accurately.

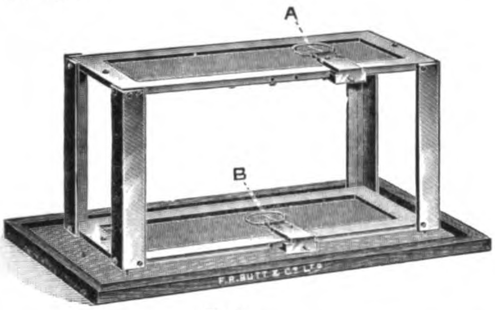


Fig. 1.

The lower ring is then moved along until its shadow registers accurately on the shadow of the upper ring.

Now the centres of the two rings, that of the foreign body and the focal point, are all in correct alignment.

The localizer is placed on its side C, D, and two straight edges (Fig. 2) are attached to the horizontal members of the frame and the two sliding rings. The former is graduated and its edge represents accurately the vertical ray. The edge of the latter represents the oblique ray.

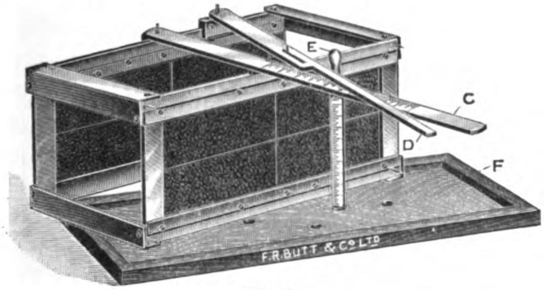


Fig. 2.

The point at which the two edges intersect represents the position of the foreign body below the surface of the wooden platform and the depth is read off on the scale.

A small graduated rod E is passed through the platform and the distance to the skin is read off. This is deducted from the former measurement to get the exact depth from the skin.

The tube may be shifted in both directions and two readings taken if great accuracy is required.

Capt. FINZI said that, without wishing in any way to criticise this new device, he could not but comment on the apparent absence of protection. It looked a very dangerous instrument, because the operator would be continually exposed to the rays. Perhaps it had some protective appliance which Major Stowe had not mentioned.

Major STOWE said that the lead glass would ensure its absolute safety. The rays came out in a very small beam, and the operator was not directly over the point of emergence except for a moment. Indeed, the procedure was so rapid that he did not think he himself would object to using it even without the glass.

RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Cancer Hospital (Free), Fulham Road, S.W., on Tuesday, April 3rd, 1917, Captain C. Thurstan Holland, M.R.C.S., President, in the chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society:—Miss ELIZABETH SEMENS, Dr. BURROWS, Capt. GEORGE MUSSON.

NOMINATIONS.

ARTHUR SCHIFF, 44, Bedford Row, W.C.
Proposed by CHARLES A. SCHUNCK.
Seconded by J. H. GARDINER.

DALTON RICHARDSON, M.D., 19, Chalfont Court, Upper Baker Street, N.W.
Proposed by R. KNOX.
Seconded by R. W. A. SALMOND.

HAROLD COURTNEY GAGE, Radiographer, Hôpital Militaire, VR 96, Ris Orangis.
Proposed by Sir JAMES MACKENZIE DAVIDSON.
Seconded by by G. H. RODMAN.

CAPTAIN GILCHRIST, Assistant Professor of Physics, Ontario University; X-ray Department, Ontario Military Hospital, Orpington.
Proposed by LT.-COL. WILSON.
Seconded by R. KNOX.

A discussion then took place on "The Future of the British X-ray Industry." Mr. Geoffrey Pearce opening the discussion as follows—

THE FUTURE OF THE BRITISH X-RAY INDUSTRY.

By GEOFFREY PEARCE.

Mr. President, Ladies and Gentlemen:—The title of the discussion to-night would indicate an attempt to prophesy, but this is not the intention, which is rather an endeavour to survey the past and the present with a view to preparing for the future.

Perhaps the best point to commence is a review of British X-ray industry in the year 1914, immediately prior to the outbreak of war, and having considered the situation at that time, it will be easier to contemplate the future. My endeavour, therefore, is to lay before you the various problems with which, to my mind, we are faced.

In using the term "we," I do so advisedly, for this Society has the advantage of a composite membership, consisting of surgeons, physicians, physicists and representatives of manufacturers, and I plead, therefore, as a fundamental principle, for a closer co-operation to attain the ends which we all have in view.

The British X-ray industry has, I venture to say, suffered in the past severely from foreign competition; notably from the country with whom we are now at war, and probably the causes which were responsible for this state of affairs are very similar to those applying in general to other industries.

Before the war, German X-ray and electro-medical apparatus was imported, not only into this country in large quantities, but also into our colonies. In exactly what proportion I am unable to state, as, unfortunately, very few statistics are available; but I have been able to secure from the official trade returns of Germany statistics showing the export of electrical apparatus for medical and dental purposes which are of interest.

The figures relate to the years 1912 and 1913, and we find that her total exports in the year 1912 in this class of goods amounted to £177,400, increasing in 1913 to £228,200, an increase of over £50,000.

Taking the year 1912, Austria-Hungary was the largest importer, receiving nearly £38,000; Russia came next, importing £30,000; the United Kingdom coming third with £14,000 in 1912 and about £19,000 in 1913.

It has been estimated that 50 per cent. of the apparatus used in this country was foreign, but in the absence of properly analysed trade returns, such figures are only guesswork.

The problem before us, therefore, is to consider the various conditions which have led to such a large proportion of foreign-made apparatus being used in our own country.

In my opinion, it is not due to a single circumstance, but rather to a number, all of which have combined to produce a state of affairs which we intend shall never be repeated.

To come to the important point, therefore, why has the foreign-made apparatus met mith the favour which apparently it has enjoyed in the past? Is it better than that which we can produce ourselves? So far as workmanship is concerned, we can give an emphatic negative to that question, but I venture to suggest that new appliances have not, as a general rule, originated in this country, but elsewhere. We have, in fact, followed the lead of the Germans and others.

The application of the alternating current high-tension transformer, combined with a chemical or rotating rectifier, was the result of the work of Koch, of Dresden, and improvements by Snook, of Philadelphia.

The heavy discharge induction coil with the large iron core and other modifications was not made here until Dr. Reginald Morton's article in one of the leading medical journals, following his visit to the States, woke us up to what was being done in America.

One of the latest and perhaps the most recent of improvements is the Coolidge tube. This is the work of an American, and it has a German rival in the Lillenfeld tube.

The most popular X-ray tubes used before the war were either German or made by German-controlled agents, and to-day the American tube enjoys considerable favour.

Apparatus for single flash exposures was never seriously tackled at home, although

appliances for this particular class of work have been made for some considerable time on the Continent.

The names given to the various instruments for the estimation of exposure and dosage, such as Wehnelt, Walter, Bauer, Benoist, Holzknecht, Sabouraud, etc., are obviously not English.

Germany's geographical situation has had no small part in advancing her electro-medical industry. Her clinics have attracted medical men from the surrounding countries. Not only was access easier to them, from a geographical standpoint as compared with our own in most cases, but in certain instances they spoke a somewhat similar language, and transport was an easier matter from Germany than from the British Isles. It is quite easy to conceive, therefore, that Germany was visited by medical men from such countries as Holland, Denmark, Norway, Sweden, Russia, Turkey, etc.

This opened up a very large field for the supply of X-ray and electro-medical apparatus, and the consequence was that the German manufacturers were enabled to develop far larger concerns for the production of such than could be contemplated in the United Kingdom.

This state of affairs enabled large factories to be erected and equipped, which were capable of turning out quantities of apparatus, and owing to their size they were able to employ a highly-trained technical staff, not only to supervise production, but to carry out investigation and research.

Another large field for the distribution of Germany's electro-medical apparatus was Italy, Spain, South America and even the United States.

I am inclined to think this was, to a certain extent, due to the fact that students from these countries frequently attended the German Universities for their training, and, naturally, when returning to practise in their own country, preferred to use appliances with which they were familiar; or probably returned in later years to take post-graduate courses in Röntgenology in the land of their Alma Mater.

Having, therefore, established a large field in which she could dispose of her manufactures, Germany settled down to construct appliances on a large scale, backed by a highly-trained technical staff, with the inevitable result that as a rule, she not only instituted new technique, but improved existing apparatus, invented new, and on account of the size of her factories, she was able to produce at a low cost and export apparatus to this country freely, and without any disability in the direction of tariffs, whilst similar facilities were denied to us, had we been in a position to export from here.

I will give you one instance, possibly a small thing by itself, but it serves to illustrate the help which was accorded to German manufacturers.

A German house wishing to send X-ray tubes to this country, could do so most economically by forwarding through the German Imperial Parcel Post. A large tube could be enclosed in a light wood case, the cost of which was very small; but the maximum size of a parcel allowed by the British postal authorities prohibited a case of such dimensions. The German parcel post, therefore, contracted with a firm of carriers at the British port of entry, who took over the package and delivered it to the consignee; the only cost being a few marks charged by the German Parcel Post.

So far so good. What happened if one wished to send a similar tube to Germany? It was not possible to do so by this means. The British postal authorities would not accept the parcel by reason of its size. There was no means of forwarding the tube except by a carrier, whose charges were much heavier than the German parcel post rates; and by reason of the rougher treatment to which the case was subjected during its whole transit by the carrier it was necessary to pack it in a much more substantial and consequently heavier and more expensive packing case.

This in itself may appear to be a small matter, but it serves to illustrate the manner in which German authorities helped her manufacturers to forward their goods, not only to this country, but to all the different countries who were purchasers of her products.

I have no knowledge of the matter, possibly some of the gentlemen who follow me will be able

to give some information, but I am under the impression that the German hospitals received grants from the State, which enabled them to equip their X-ray departments on a more generous scale than the hospitals in this country.

Having, therefore, surveyed the German conditions, what about our own ?

Röntgenology is one of the newer branches of science, and has therefore been subject to constant change and development since its inception.

When the world-famous discovery of X-rays was made, the appliances used to produce the phenomenon were laboratory instruments, and it is therefore not surprising to find that the manufacture of X-ray apparatus was taken up to a certain extent by firms who previously had produced this class of instruments, and therefore for some years we find that in many, although not in every case, the manufacture of X-ray apparatus was run as a branch of other businesses.

As the science developed, so the apparatus increased in size and power, until at the present day its construction demands an engineering works.

Manufacturing houses in this country have done their best to keep pace with the developments, but in the absence of properly trained and efficient technical staff, they have, in many directions, although not entirely, fallen short of their foreign competitors.

On account of the strength of foreign competition it has not been possible to produce in sufficiently large quantities to develop the industry on the proper lines, and, what is of the greatest importance, to employ a trained staff who would be occupied mainly upon investigation and research for the purposes of the improvement and perfection of apparatus.

The present time, is of course, abnormal. The demand for X-ray and electro-medical apparatus has been on a scale which was never anticipated three years ago, and has enabled manufacturers to take up the construction of apparatus on entirely different lines ; and I submit that steps should be taken to ensure that this demand continues. I am quite sure that this can be achieved, and there is no reason why British-made X-ray apparatus should not be pre-eminent and used all over the world.

This is the goal, therefore, which we have to set before us. How is it to be achieved ? I have repeatedly referred to research. In my opinion this cannot, and should not be, undertaken by individual manufacturers, but on a properly organized plan, the benefits of which would be enjoyed, not only by the manufacturers themselves, but by the users of the apparatus.

We all owe a debt of gratitude to certain physicists who have interested themselves in some matters, and also to the X-ray Committee at the War Office, who have done much to organize supplies and to a certain extent to standardize apparatus. If such work, for instance, as has been done in connection with protective appliances, from which we have all benefited, was consistently carried out in other directions, the benefits would be incalculable.

Research and its application to manufacture is all important, but another very important point is propaganda and publicity ; in other words, having produced the goods, special consideration should be given to the manner in which they are presented to those who have need of them.

X-ray and electro-medical apparatus is not sold by newspaper advertisement.

A means should be found of attracting the attention of radiologists from all parts of the world to this country ; not necessarily entirely by personal visits, although it would be extremely useful to have clinics with post-graduate courses of such reputation as would attract visitors from foreign countries, but much can be done in the way of literature.

There are two publications in this country devoted to the subject, and I suggest it would be advantageous to compare these with publications from Germany, France and America.

The foregoing remarks will indicate how badly the manufacturers require the closer co-operation and assistance of the medical profession and the physicists.

I am not here to praise the works of the enemy, but comparison is always useful, and

I have frequently wondered whether we should ever see in London anything of the nature of the Röntgen Congress in Berlin.

The Congress takes place on Sunday, and the large theatre is packed from nine in the morning until ten o'clock at night. Of the atmosphere I will say nothing, but the enthusiasm is extraordinary.

That we shall have to face strenuous competition in the future is unquestionable, not only from the European Continent, but also from America.

Quite recently a consignment of X-ray tubes formed part of a prize seized by our Navy. Although these tubes were consigned from a neutral country, there is no doubt that they originated from an enemy manufacturer, showing that even at the present time Germany has enough tubes for her own purposes and to spare, and is trying to export them.

The Americans have big factories as well as Germany, employing hundreds of hands and turning out expensive apparatus on a large scale. In one factory which I recently visited, I was very much impressed by a form of combined table and upright screening apparatus costing £250 each. These tables were being put through the works in lots of twenty at a time, and as soon as one lot was completed another lot was put in hand.

There has recently been a fusion of interests in the United States, four large companies being formed into one corporation. What are we to do to meet this ? Is some form of combination desirable ? Some pooling of interests for the purpose of conserving our energies and benefiting as a whole in an Empire and world-wide trade ?

May I give you one more example of what should not exist. One of our largest, richest and most important colonies uses almost entirely foreign-made apparatus. I refer to the Dominion of Canada. The country is regularly visited by representatives of American manufacturers, and so important has this field become that one house is making arrangements to open offices in the colony. Is this to continue ? Preferential protective tariffs by themselves will not open such fields to us.

As many of you are aware, the English manufacturers have recently formed a section of an organization which exists in the interests of the electrical trade as a whole in this country, and much useful work has already been done and will be done in the future.

While no doubt this organization will do much to check and meet foreign competition at home, it is obvious to all, and I desire to emphasize this point, it is only by a participation in a large share of the world-wide trade that a sufficiently large output can be secured, to enable us to put the industry on such a footing as will enable it to occupy the position it should and develop as the scope of the science increases.

In conclusion, I should like to place the following considerations before you :—

(a) The best means of avoiding a repetition of the condition of the industry previous to the outbreak of war.

(b) What steps should be taken to carry out research and investigation, to ensure British-made apparatus being supreme.

(c) What action can be taken by radiologists, physicists and manufacturers, either individually or collectively, to—

(1) Derive the greatest possible benefits obtainable from the practical application of research.

(2) To secure, not only a home market, but an Empire and world-wide trade.

How can this Society further this end ?

DISCUSSION.

Professor Alfred W. PORTER, F.R.S.: Although I represent academic rather than manufacturing interests, I find myself in almost complete agreement with the views expressed by the opener of this discussion. It fills one with a lively satisfaction to realize that Britain is at last wakening up in regard to her manufactures, even though it has required a war to awaken her.

Mr. Pearce has emphasized the need for research if Britain is to secure the world's trade in X-ray manufactures. It is not by copying existing models that this result is likely to be achieved. The model of the future will probably

be as different from the Coolidge tube as that is from its predecessor. No one knows what this model will be; it is only by research that it can be found out; and our supremacy in the world's trade depends upon its discovery. This Society has many responsibilities, one of which is to see to it that the manufacturer is put into the way of utilizing without delay the result of discoveries that are made in the laboratory. It is in this respect that we have fallen behind and other countries have stepped in.

To ensure this close association between the academic and manufacturing sides requires the institution of research laboratories in works themselves. University laboratories already exist and fulfil their function of instilling the research spirit into men (*e.g.*, Owen Richardson's laboratory at King's College; the work done by Professor Richardson on thermionics has culminated in the invention in America of the Coolidge tube). But manufacturers in other branches are finding that these are not enough, because these researches do not as a rule come into contact with manufactures. In some trades this state of things is already being rectified. The tendency is for large firms to provide research laboratories in their works, which are not concerned merely with the improvement of existing designs, but in which the assistants are encouraged to strike out on new lines which at first may seem perfectly useless. In these establishments men of picked ability are employed. Witness the research laboratory at the Kodak Works in Rochester (N.Y.), (with Dr. C. E. K. Mees at its head), and the laboratories of the General Electric Company in America. In England I know of one optical firm who has started such a laboratory and has appointed as its scientific adviser a mathematical physicist of great attainments and international reputation. It is laboratories of this kind which are wanted in the X-ray manufacture. Unfortunately there is the practical difficulty that most firms are on too small a scale to afford to institute them. The only solution to this problem is that some kind of association shall take place between the smaller firms. The existence of small grocers and bakers is useful because of the need for house-to-house distribution; but there is not the same justification for the small X-ray manufacturer. Co-ordination between small firms seems to be an absolute necessity if British manufacturers are going to capture the world's trade.

Of all the interesting points made in Mr. Pearce's remarks I was specially pleased to find that he did not rely on protective tariffs as the panacea which is to bring Britain into her own in the X-ray industries.

Mr. R. S. WRIGHT: When Dr. Knox asked me to contribute to this discussion, I promised to do so, and since then I have been wondering as to what I should say. I think I had better start at once by saying that I propose to make some remarks which I am afraid will not be altogether palatable. It is the first time in my life that I have had the opportunity of speaking to medical men about their faults and failings. In this Society and elsewhere I have listened patiently to medical men who have spoken of the shortcomings of the British manufacturer, and I have felt that I would like to retaliate, but have never been able to do so until to-night. I think we shall all admit that the position before the war was very unsatisfactory. Two-thirds of our X-ray apparatus came in from abroad; and I take it we are all here to-night to discuss how that can be avoided in the future. We must start by trying to find out definitely what was the matter. To my mind one very big thing has been the matter, and I can speak from a good deal of experience, because I have been actually making X-ray apparatus since early in 1896, which is earlier, I think, than all except a very few can go back to. During all that time I have been doing my very best to manufacture and not to import. Broadly speaking, the biggest obstacle of all to the carrying out of such a policy—I am convinced of it—has been not the British manufacturer, but the British medical man. British medical men have had a rooted idea in their heads—and half of them never seem to have succeeded in getting it out—that a thing made in England must be behindhand. If a hospital has been

going in for a new installation it has been the habit of the medical officer in charge to make a tour of the Continent in order to see what is in use in continental hospitals, and then it is decided on his recommendation that the continental installation must be put in and nothing else. A month or two after the war broke out—it was either in September or October, 1914—there appeared in the *Archives of the Roentgen Ray* an editorial lamenting that the medical men of Great Britain were separated for a time from their contienental colleagues, "the pioneers and masters of their art." I remember the very expression because it has been sticking in my throat ever since. "The pioneers and masters of their art!" Of what nationality is Sir William Crookes, who laid the foundation for the discovery of X-rays? Of what nationality is Professor Jackson, the inventor of the focus tube? Of what nationality is Sir James Mackenzie Davidson, the originator of all localizing methods? Of what nationality is Nicola Tesla, the first inventor of the turbine interrupter? Granted that the Germans have done their share towards advancement, yet other nations, including our own, have done their share as well. Following upon the Amsterdam or the Berlin Congress of Roentgenology, I forget which, we were told in the presidential address to the Rontgen Society in that year, that we might congratulate ourselves that English doctors were not merely spectators. One English doctor was actually asked to become a president of one of the sub-sections! What an honour! We were told that we must congratulate ourselves upon that honour paid to the English doctors. How many German doctors were asked to become presidents of other sub-sections? Now, sir, I think that that feeling among British doctors, that they must adopt everything that German doctors adopt, and that the German methods must be best because they are German, and that if an English maker shows any originality it cannot be taken up until the German doctors have endorsed it —I think that that has been the great evil. I will give one definite and concrete instance. I must apologize for mentioning a matter in which my own firm was concerned, but every man naturally knows his own business best, and the best illustration I can give is obviously one with which my own business experience has made me most familiar. Everyone knows of the Snook interrupterless machine. It was first put on the market in its present form by Mr. H. Clyde Snook, of Philadelphia. I heard of that machine before it made its first appearance in Europe. I heard it was a good thing, and I made up my mind that my firm should have the honour of being the first European firm to manufacture it. Mr. Snook had brought it over for the Roentgen Congress at Amsterdam, and I went over to Amsterdam about it the night before the Congress opened. It was the roughest night on the North Sea in the memory of the oldest sailor on board, and Dr. Knox, who was a fellow-passenger with me on that occasion, will agree that it wanted some little determination to cross on such a night. But that machine was going to be demonstrated in Amsterdam the next morning, and I meant to have the manufacturing rights. I got there; I saw Mr. Snook, and I went back the next night with a draft of an agreement already in my pocket. Within a few weeks I got the first drawings from America. We started manufacturing the apparatus in our London workshops and very shortly placed it on the market. Nobody bought it. It is true that we sold one or two; but, broadly speaking, nobody bought it. One of Mr. Snook's machines—and only one, I think made its way into Germany; it was bought by Albers-Schönberg. I believe it was bought mainly for the benefit of the German manufacturers. The German doctors meant to have it, but no German doctor or hospital would buy one either from us or from Mr. Snook. They were all waiting and were determined to wait until the German manufacturers were ready. The German doctors would not buy it because it was not being made in Germany, and the English doctors would not buy it because Germany had not adopted it. In the course of several months two or three German firms brought out the same type of apparatus. I have got here a cutting from our old catalogue

of that year with an illustration of our apparatus on the top, and underneath I have attached an illustration of the apparatus as a German firm had copied it. You will see that they had copied it down to the very panelling on the woodwork; they had copied it down to the very last screw! Immediately that came out in Germany it sold in dozens all over the country, proving that the doctors had only been waiting until the German manufacturers were ready. Then the English doctors woke up; the hospitals began to put it in, and two-thirds of them went to Germany for it! At the end of the first year I think we had sold five, and one German firm who started six months after we did had sold thirty-seven. Yet we had introduced that instrument into Europe. Was that the fault of the British manufacturer, or was it the fault of the British medical man? I can see very clearly that the British medical men were waiting until the German doctors had adopted it, and then they went to Germany for it. The difference is just this: the average German doctor has it firmly in his head that it is his business to keep German manufactures uppermost; he is as keen upon it as is the German manufacturer himself. He regards it as a part of his definite personal responsibility. It is all *Deutschland über alles*. We can say what we like about the Germans, but the whole population have this idea rooted in them. Speaking as a practical manufacturer, I say that the German hospital and the German doctor will *not buy* a piece of apparatus that is not made in Germany. The foreign article may be better, it may be cheaper, but they will not buy it. The German doctor is out for the prosperity of the German nation as much as the manufacturer himself. Although the latter makes his living through manufacturing and the former is his customer, the two work together. I remember once getting a specification sent to me by a doctor in Harley Street for a hospital installation; it was so worded as practically to mean that every item had to be of German manufacture. I thought it a great shame and protested, and I got properly sat on. This is the substance of the letter I got in reply to my expostulation: "Dear Mr. Wright, In reply to your letter, the hospital in question is the German Hospital in London, and the committee have quite naturally made up their minds that every piece of the apparatus should be as far as possible made in Germany." I could only write back and say that I wished I could find one of our own hospital committees equally patriotic. May I remind you of an old chestnut? A costermonger had his barrow upset and his goods smashed up. A crowd gathered round, and people said that they were very sorry. A gentleman then took off his hat and went round among the crowd saying, "I am sorry five shillings. How much are you sorry?" We are all here to-night to talk of ways and means of benefiting British manufacturing. We have already been told that the manufacturers ought to combine and set up better laboratories. May I ask you medical gentlemen, how much are you anxious to help the British manufacturer? Are you anxious to the extent of a ten per cent. difference in price after the war? Are you anxious to the extent of waiting for a few months if the article is something which the German manufacturers have in stock and we have not? Are you anxious to the extent of forming a medical association and coming to an agreement not to buy anything made abroad which could be made at home? Are you anxious to the extent of resigning from any hospital which buys a foreign-made piece of apparatus that *could* be made over here? Will your anxiety take a definite and practical form such as we British manufacturers have a right to expect? I have been anxious about British manufacturing for years past. I have lost hundreds of pounds over it. I have insisted on making things in this country which I could have got more cheaply abroad. I have lost a great deal of money in my determination that everything in which my firm deals should be made so far as possible in this country. If you on your part are anxious *enough*, I will venture to say that in five years' time you will not talk about British electro-medical manufacturing being behindhand.

Sir JAMES MACKENZIE DAVIDSON: I must apologize to you, sir, for not responding

to your call earlier in the evening, but really this discussion appeared to be concerned chiefly with trade interests, and, of course, being a medical man, in these I could take no active part. But after Mr. Wright's attack on my profession perhaps I may just say a word or two. As regards the Snook apparatus, I should like to point out that the fact that it came into favour not at first, but later on, was not entirely due to its re-introduction from the Continent. When the Snook machine first came out, there were very few tubes that would stand the energy it put through them, and as medical men are not very well off as a rule, they could not contemplate the expense which was involved by its constant use. But in the process of development of tube construction we have now arrived at a tube quite equal to the energy which the Snook machine puts in, and no doubt that form of machine will come into more general employment. Nevertheless, I admit the main ground of Mr. Wright's contention. Take, for example, the case of radium. We used radium at Charing Cross before it was used in Paris, and Darier, of Paris, came over and saw our method of using it. But later Sir Frederick Treves and Sir Malcolm Morris went over to Paris and came back and told of the methods and results, and the thing got into the *Daily Mail* and everybody was agog on the subject of radium. We had been quietly using it in the course of our ordinary work at Charing Cross for a long while previously, but, being of British origin, it was ignored. But I trust that in the reaction from this extreme we shall not swing over to the other and become too exclusive. It is true that fundamentally this is an industrial war. The Germans have been waging war on us since long before the outbreak of military hostilities, and undermining us in every country by dishonest ways. They have believed themselves to be absolutely superior, though I think that in their attempt to become dominant they will be destroyed, and that very soon. In my own special branch of surgery there has been a tremendous belief in German oculists—but that was the opinion of the public rather than the profession. I do not think myself, from actual knowledge of both fields of work, that the German oculists are superior to our own. With regard to X-rays, Mr. Wright has said that we would not accept anything until it had been taken up in Germany. But I do not think that will be the case in the future. The German X-ray tubes, we must admit, have had a superiority over those made elsewhere, but our American cousins—our allies now—have made a tube which will hold its own against any German tube or any other tube for many a day. Then there comes the question of the relationship between the medical men who use X-rays and the manufacturer who makes the apparatus for him. The relationship is a little different from that obtaining between the surgeon and the maker of surgical instruments, for the surgical instrument-maker does not amputate legs and arms, whereas in the case of X-rays the manufacturer of instruments may also be applying X-rays for medical purposes as a side branch of his business. Laymen are placed in large hospitals to control the X-ray departments, and very likely they can produce much better technical photographs than some medical men, but they are quite incapable of giving any medical opinion unless they have been a long time at the work and have picked up a smattering from the medical men who have been placed over them. Some people in authority do not recognise the difference between the operator and the medical man who has got to interpret what he produces. I am afraid that is the case at the present time. Then, again, if a medical man were to run a business as X-ray manufacturer as a subsidiary branch of his professional work there would be a good deal of friction, and it is only natural that the younger medical men should regard with no very tender feelings the layman who is producing photographs for medical men at lower rates. But whatever friction there may be on these scores between medical men and laymen, a society of this kind which brings together the medical men who want apparatus and the manufacturers who are making it fulfils a distinct rôle, and the mutual interchange of thought must be very helpful. I trust that the goodwill between medical men

and manufacturers will after the war tend to keep our own manufacturers fully employed, and that their apparatus will be widely used. But, of course, one of the beauties of the Englishman's ideal is his policy of live and let live, and we are not going to imitate the Germans and say that no one can produce anything worth while except ourselves. We shall probably go on buying apparatus from various sources after the war, but I do not think that when the war is over we shall resume the buying of things German!

Capt. G. W. C. KAYE: Mr. Pearce's remarks are so eminently reasonable that they can excite little controversy. We have in the first place to find out what was "rotten in the state of Denmark" before the war. It has been part of my work in the past to digest almost every paper on X-rays published in Germany and in this country and America and France. I was interested to see which nation had contributed most to the literature of the subject. So far as the pure physics of X-rays is concerned, right away from the very first the English have held their own. We have, I think, taking it all in all, produced a record in the shape of papers which are of paramount value in this branch of the subject. Of this part of our work we need not by any means be ashamed. But if one consulted German papers and bibliographies alone, ignoring those of other countries, one would get a different impression as to the value of English research. The spirit of "Deutschland über alles" has always been conspicuous in German scientific literature. English, French and American names are conspicuous by their absence. And, unfortunately, the German idea of dominance and supremacy has impressed our colleagues in France, who believe that one must go to Germany for really original research. Very little indeed is known in France of the work done in this country either by physicists or medical men. It is a thousand pities that pure physics should seem to some people to be more or less in the clouds and of little value, making the man who devotes himself to this subject a thing apart. Pure science is an essential preliminary to work of practical value, but its merits in this connection are rarely appreciated.

Now, if one comes to the applied side of the subject and analyses the literature of various countries, it will be found that the X-ray papers published in this country are comparatively very few in number. The X-ray manufacturers will agree with me in this, that on the applied side we have not done a great deal of pioneer work. I do not enter into the reasons for this, whatever they may be; the manufacturers may tell us what the difficulties have been. At all events we have done little in applied physics. On the other hand, if you go to Germany, and more especially of late years to America, you will find a very different state of things. One factor to be borne in mind is the relative sizes of the countries, and that no doubt comes in.

The question is, what are we going to do to alter this state of things? Personally I do not think we shall get a great deal of help in the future out of purely academic circles. In university laboratories the researches undertaken are mostly pioneer work, some of it absolutely useless at the time, though it may possibly be useful some day. What is wanted is a laboratory to which manufacturers can go with some assurance that their difficulties will be met and studied in a sympathetic spirit. A laboratory of that sort is too great an undertaking for the individual firm in this country. Possibly we may get that co-operation between X-ray manufacturers which Professor Porter has forcasted. We may then get an X-ray Institute or something like it, whose particular province it would be to thresh out these problems. But it can hardly take shape unless this Society—which is the one to do it—is prepared to enter upon some practical steps. I hope that some scheme may be found practicable, and that the result of the discussion this evening may lead ultimately to some institution which will be acceptable to the medical men—for whom, by the way, we are all working—as well as to the manufacturer and, to the research worker who is engaged upon

the subject because he loves it and because he hopes to make it yield something of practical value in the future.

Mr. CUTHBERT ANDREWS: I should like to thank Mr. Pearce for his enterprise, and perhaps I may add, his courage in opening this discussion, and I feel sure that nothing but good can come of ventilating these matters in which we are all so much interested at the present time. There is one aspect which cannot be, I think, too strongly insisted upon, and that is the interdependence of the medical profession and the manufacturers. The one body is clearly the complement of the other, and only by the full recognition of this fact by both sides will smooth and efficient working be achieved. If this debate should assist in the establishment of a closer understanding between these two branches, the benefit to both will be very considerable. So far as I am personally concerned, I have always received the greatest help from the profession; but I am inclined to doubt whether there has been between the trade as a whole and the radiologists as a whole that degree of co-operation which has existed in other countries.

Manufacturers are often criticized for their lack of imagination when manufacturing, and excess of it when framing prices, their slowness to adopt suggestions, and so on. I am not sure that this is justified. Some of us have found that we are not clever enough to make a living in a respectable way, and so we have gone into the electro-medical business, for, I fear, sordid ends. Courses which may appear desirable and possible from an academic standpoint may be hopelessly unsound in business, where there are technical difficulties to be considered, and a hundred traps for increasing costs to be avoided. Our members occasionally exhibit most valuable and interesting pieces of home-made apparatus constructed from nursery or kitchen loot—admirable as the work of an amateur for his own use; but a manufacturer can scarcely place an exact replica of that apparatus in his catalogue. He must re-design the two knitting-needles and the piece of soap, and perhaps spend a considerable amount of money on producing an article the original workable model of which may have been made for 4d.—excluding labour at professional rates. He perhaps makes twelve of these new appliances, sells two while the boom is at its height, and finds that the inventor has made a slight improvement which scraps the remaining ten, which therefore serve him as horrible examples for the rest of his life.

At present in this country we have a small number of separate firms, none of them very large as businesses go nowadays, each working independently for a comparatively small clientèle. Up to now there has been little or no co-operation, and therefore no chance of economizing or simplifying production so as to enable these firms to compete properly in the world market. How can such methods hope to succeed against the huge concerns of Germany and America—the A.E.G., Sanitas, Reiniger, the Victor—with their standardized apparatus, large output, experimental facilities and world-wide representation? The British conditions are not due wholly to lack of enterprise. The X-ray industry is a young one, and you may have noticed that with one or two redeeming exceptions its conduct is in the hands of young men, most of whom have a fair share of ambition and the wish to build solidly for the future. I undertake to say that there is scarcely one of us who would not scrap his present methods and establishment to-morrow if he could see his way clear to re-organization on a more efficient system. Up to now, the difficulties in the way of such re-organization have seemed very great—some financial, some sentimental and some dyspeptic; but with the war has come the necessity of doing all kinds of things which we had looked upon as impossible; and it seems to me that there is now every chance of such an understanding between electro-medical firms as will enable them not only to give a vastly better service to our customers at home, but to conduct a vigorous campaign in the colonial and foreign markets. But to secure this there must be frank interchange of ideas between the profession and the various houses, an increase of respect and a decrease of suspicion, and a

mutual willingness to come into line and pull together for the good of all concerned. This must be backed by the help and interest of radiologists, who should feel as keen on improving the status of the British apparatus as the manufacturers themselves. We need research, literature and practical discussions comparable with those of other countries.

Recently there has been taken a step which is, I think, of the very greatest importance to this whole question—I mean the formation of our manufacturers' association, to which Mr. Pearce has already alluded. Only a few meetings have been held so far, but personally I am most sanguine as to the future work of this association which is justifying its existence every day.

On the subject of general electro-medical apparatus I am not qualified to speak. I am condemned to be a maker of X-ray tubes, but, thank heaven, I have escaped the extreme penalty reserved for those who embark on the sea of medical-electrical engineering. But I think it may be of interest to the members to know broadly speaking what is being done in the particular matter of X-ray tubes.

Perhaps for the benefit of the less experienced, I may offer a definition. An X-ray tube is a sphere of glass entirely surrounded by profanity.

It is probably within the knowledge of most members that there are in this country only four firms who actually manufacture tubes on a commercial scale. Prior to the outbreak of war, a large number of these instruments were imported from Germany, France and America, and those made in this country were dependent upon Germany for their material. On the outbreak of war very great difficulties arose in this connection, but fortunately we were able to surmount these, and now, with one exception, everything required for the manufacture of X-ray tubes can be produced in Great Britain. The exception is a satisfactory quality of tungsten, and here there is the special difficulty that this metal is required for other important war purposes, and apparently no firm up to the present has been in a position to produce what is needed for X-ray tube construction. No doubt this will be overcome, and we shall be then absolutely independent of outside supplies of material. Considering the high degree of perfection to which the continental—and notably the German—tube had been brought, and that we were starting practically from zero again, the tube manufacturers feel some small pride that they have been able to bring British-made tubes to their present high standard. Certainly the ideal X-ray tube is yet to seek. In spite of all our endeavours we do not seem to provide tubes that will meet and overcome all obstacles. For instance, a certain Government department recently returned an instrument saying "this was received faulty, and although our resident engineer has done his best to repair it, we cannot get any X-rays." When the tube arrived we found that the resident engineer had soldered the regulator wire to the cathode cap.

Again, a provincial dealer wrote us a few days ago saying "we put on the tube which at first seemed to be quite hard. We then heard a sharp crack, and found that all the vacuum had rushed out."

With regard to the future, the members present will be glad to know that the Ministry of Munitions is taking a very active interest in the whole question of tube production and on the whole the scheme promises well. A sub-committee has been formed consisting of most of the tube manufacturers, and this sub-committee is working in conjunction with the Optical and Glassware Section of the Ministry of Munitions. A laboratory under the supervision of Professor Jackson has been set up by the Ministry and equipped by the tube manufacturers, with the object of carrying out research work for the improvement of manufacturing methods. The manufacturers interested in the scheme have agreed to pool their present knowledge with the Ministry of Munitions and amongst themselves, and all are earnestly working for the general advancement of the tube industry in this country.

There is much to be done, and the problem is largely one of the education of suitable labour. This last is a vital question which has to be tackled immediately; but we are prepared to deal with it, and have very definite ideas as to the courses which are desirable. Personally,

I have had always the opinion that labour—highly skilled labour such as we must employ—is the sole real difficulty. All other problems can be and are being overcome in spite of the obstacles against which we have been struggling of late. But labour has to be found and trained and kept. If we can obtain the help of the Government in conserving our present skilled staffs we have a nucleus round which we can build, and that we shall be successful in training there is no doubt whatever. But skilled men must be kept in their civil employment in order to produce, and to teach others to produce. That is the vital condition. Given labour, I will guarantee that within a reasonable time we shall be freed from the necessity of importing into this country a single foreign X-ray tube. Needless to say, at the present time competition is keen, and proceeds sometimes from the most unexpected quarters. A few days ago I had a letter from an X-ray worker who stated that he was forwarding a tube for repair. In the course of a post or two a second letter arrived, saying: "Dear Sir, I am not now sending the X-ray tube referred to in my previous letter, as since writing you my chauffeur has repaired it."

Dr. G. B. BATTEN said: I should like to say at once that I agree with nearly everything that Mr. Pearce has said in his introduction. On only one point do I fall foul of him. He says that nearly all the practical ideas come from abroad. That is not the case. They come from England; they are often rejected in England, taken up abroad, and then brought back again. This is not only true in X-rays, but in surgery. Take such a procedure as saline infusion to prevent shock. That was really started at Guy's Hospital. It was taken up with enthusiasm in America, where it was largely used, and it came back here as an American invention. Now everybody is using it. I have for twenty years been working with the alternating current, and with regard to the principle of the Snook apparatus, there is no doubt that Dr. Morton was quite as early as Koch of Dresden in the application of the alternating current high-tension transformer combined with a rectifier—and so was I. As a matter of fact, a rectifier which a friend of mine and I patented in 19C0 had a rectifying device for the secondary current on this principle, but we were not successful in getting any manufacturer to take up our ideas. Mr. Pearce mentioned Sabouraud. Professor Sabouraud is a great scientist, but it is chiefly by his pastilles for the dosage of ringworm treatment that he is most widely known. Well, some of us were doing the treatment of ringworm by X-rays for four years before Sabouraud brought out his pastilles. I wrote a paper on this X-ray treatment of ringworm two years before the *British Medical Journal* would consent to publish it, and it was not before the treatment was used in other countries that they did venture to publish it, and then they did so with an apology for having held it over for so long. What are known as Kienböck's rods for the treatment of ringworm, again, are really due to Adamson and Critchley, in London. To take another matter, protective bowls for X-ray tubes were originated by Powell's, of Whitefriars. They were used in the London Hospital and afterwards adopted at other places. I must say this somewhat in opposition to what has been urged from the manufacturer's point of view. There is naturally a commercial distrust of the inventor. Not only is this true with regard to X-ray apparatus, but with regard to most other things. We are generally so frightened of the crank that we reject the ideas of the inventor without adequate examination. In America, and France, on the other hand, the idea is at least examined before it is rejected. The tendency is also to imagine that things which come from abroad are naturally best. Two or three years ago I had to get an apparatus for a treatment centre, and I thought I knew something about alternating current devices. I consulted the price lists and spent a couple of days seeing the latest models, and then I ordered the apparatus to my satisfaction. Directly afterwards I got in contact with an L.C.C. expert. "I see you have ordered some apparatus," he said, "why did you not come to me and ask me what apparatus to get?" "How long have you been engaged in this

work?" I asked. "Two or three years," was his reply. "Well," I said, "I have been doing it for twenty years." I found afterwards that he usually recommended apparatus from a firm who chiefly imported foreign goods. Let me say that the Röntgen Society is in a unique position for taking action in this matter. We have the makers and the users of apparatus together in this Society. I was myself introduced to the Society by a manufacturer, Mr. Cossor, and I regard it as a very fortunate introduction for me. At one time some of my medical friends formed an electro-medical society and a good deal of pressure was brought to bear upon me to leave this Society, because it was not exclusively professional. I replied to them that if they built a big wall around their laboratory to prevent other people from seeing in, it also had the effect of preventing them from seeing out. That, however, has all passed over. We have got the medical profession in very great strength in this Society, and the Society itself is in a very strong position through the combination of the lay researcher, the manufacturer and the actual medical user. From the fact that we can bring these three elements together into friendly concourse, without any commercial collusion whatever, we ought in the future to be able to do a good deal towards making the best apparatus in the world available for use in this country. Somebody has said that we ought not simply to copy what other people make. Well, let us British people also not copy the Germans in their selfishness. Let us do the best we can for our patients. I hope we shall always be able to use the best apparatus possible wherever it comes from, but I hope also it will come from our own country and from the countries of our allies, including America.

RÖNTGEN SOCIETY.

A GENERAL MEETING of the Society was held at the Cancer Hospital (Free), Fulham Road, S.W., on Tuesday, May 1st, 1917. the President, Captain C. Thurstan Holland, M.R.C.S., in the chair.

The minutes of the last meeting were read and confirmed.

The following were unanimously elected members of the Society:—MR. ARTHUR SCHIFF, MR. H. C. GAGE, CAPT. GILCHRIST, DR. RICHARDSON.

NOMINATIONS.

PHILIP CHARLES KENT, Electro-Medical Engineer, 2, Fordhook Avenue, Ealing Common, W.5.

Proposed by GEOFFREY PEARCE.
Seconded by ROBERT KNOX.

The PRESIDENT (Captain Thurstan Holland), in re-opening the discussion, said:—

Ladies and gentlemen,—In re-opening the discussion on "The Future of the British X-ray Industry," I shall in the first place recall to your notice the scope of the discussion which was initiated by the admirable paper of Mr. Pearce at our last meeting.

Perhaps you will remember that the latter, after reviewing the position of the industry in 1914 for the year before the war broke out, pointed out how much we in Great Britain had suffered from the severity of German competition; and this not only in respect to our actual home trade, but even more especially as regards our foreign trade and our trade with our own Colonies and Dependencies. Very striking figures were given, figures which must of necessity appeal to, and even appal, us.

Mr. Pearce showed us that the central position of Germany of itself gave her great advantages in competition upon the continent of Europe—advantages increased by a government far-sighted in its efforts to increase German trading possibilities. And he contrasted this Government with our own in respect to the facilities given to German traders and manufacturers by their Government, facilities in trade which our own Government did not offer to our home manufacturers. Finally, after a very lucid, moderate, and reasoned picture of the past, present, and future, he suggested that the lines of the discussion should be directed to the following considerations:—

(a) The best means of avoiding a repetition of the condition of the industry previous to the outbreak of war.

(b) What steps should be taken to carry out research and investigation, to ensure British-made apparatus being supreme.

(c) What action can be taken by radiologists, physicists, and manufacturers, either individually or collectively, to—

(1) Derive the greatest possible benefits obtainable from a practical application of research.

(2) To secure, not only a home market, but an Empire and world-wide trade.

On the whole the discussion which followed Mr. Pearce's paper was valuable, interesting, and especially in its latter moments—I refer to the contributions by Dr. Batten and Mr. Cuthbert Andrews—amusing.

We had the views of scientists like Prof. Porter and Capt. Kaye; and it was with pride and satisfaction that I gathered from both these gentlemen that from the research point of view, far from being behind other nations, we could claim justly the most original and the most valuable work. And that in contradistinction to the German, our claims were put forward in a modest and straightforward manner which compares most favourably with the intensely selfish, intensely egotistical, and essentially untruthful, methods adopted by the workers of this now bubble-pricked community of self-styled "Supermen."

Mr. Wright—as you will remember—made a scathing attack on my own profession, and seemed to take a delight in unbosoming himself of ideas which had evidently been for many years seething within him. I think it is fortunate that Mr. Wright had at last an opportunity of thus giving vent to his long bottled-up feelings, and I have no doubt that all the medical members of this Society who listened to him felt the better for the attack, and relieved that this opportunity had come to Mr. Wright before the strain of suppression had become altogether too much for him. Personally, Mr. Wright may rest assured that it will be impossible for me ever again to buy anything connected with X-ray work which has not got the hall-mark of his approval. Not even a Coolidge tube. At the same time I cannot admit that Mr. Wright's "eulogistic" opinion of British medical X-ray *men* was altogether deserved.

The gist of his criticism was, if you will remember, that we medical men had a rooted idea in our heads "that a thing made in England must be behindhand." Personally, I cannot allow this to pass. I always bought that which I considered to be the best for the purposes to which I intended to put it. Mistaken, of course, I may have been—it may not have been the best—but mistaken or not, this was my reason for buying.

The original Snook machine was cited as a typical example of our misdeeds. In this respect I had one of the earliest made by Mr. Wright's firm, and have nothing but praise to say of a machine which has never given any trouble, which has never cost anything in repair, and which stands to-day in the excellence of its output as a striking testimony to Mr. Wright's foresight and to the good work of his firm.

But—and it is a large but—at the time this machine was bought it was by no means a machine for general use. Its cost was great, it was impossible to use it as the sole X-ray generator—and a coil outfit in addition was essential. No tubes then in existence would stand up to it for general use, either in private or hospital work. It wrecked tubes and could only be used for special work. It is hardly to be wondered at that both hospitals and private users hesitated to buy.

Sir Mackenzie Davidson raised a most important point when he spoke of the relationship between medical men who use X-ray apparatus and the manufacturers who made the apparatus for them, and here I would retaliate on the manufacturers.

My experience extends over a period of twenty years, and the charge I would bring against English manufacturers is that they do not sufficiently make themselves acquainted with the requirements of X-ray work.

Let me illustrate this by an example to make my point. An English firm supplied the last thing in large coils for a hospital installation in

which I am interested. Price was no object. When the coil came down it proved quite unsuitable for ordinary X-ray work, although the output was enormous. The makers informed me that it was capable of giving an enormous milliampèrage—so it was—but unfortunately it gave also such an enormous inverse current that no valve tube could cut it out. Here the manufacturers failed. They tested the coil by laboratory tests, by theoretical tests. As a practical working coil for taking radiographs and doing the everyday work of an X-ray establishment it was a hopeless failure.

The supreme test for use had not been made. No practical test of its capacity for X-ray work as made by a medical expert had been made. This is merely an example; my point is that British manufacturers do not set up their apparatus from the medical expert's point of view—do not employ a practical worker to test their apparatus in the workshop before it goes out. And what is more, they do not do so at the present time.

I venture to suggest that German firms do consult, and consult frequently, recognised medical experts. And it is to my own certain knowledge that many firms in Germany have in the past fitted up the hospital and private installations of certain experts free of cost, in order to make sure that the instruments they proposed to put on the market served their purpose, on the principle that payment was to be made if the apparatus was kept.

No British firm has ever done this. Hamburg has been a typical example of this kind of thing.

We all, I am sure, listened to the breezy humour of Dr. Batten and Mr. Cuthbert Andrews with pleasure and delight. The latter's description of an X-ray tube as a "globe of glass surrounded by profanity," deserves to become historical. But though we laughed with Mr. Andrews at this and other sallies there was much more in his contribution to the discussion, and his optimistic opinion of the future of X-ray tube making in England was cheering to British ears. That our Government has had the foresight to back the undertaking is a promise of better things to come.

After these few words of introduction by way of shortly indicating the general scope of the discussion as far as it went, I wish to endeavour to make some slight contribution on my own part as to my own ideas of the lines on which we should all act in the future.

To my mind neither the initiator of the discussion, nor the speakers who followed him, really approached the subject of the future in a very practical manner. To begin with, the suggestions of Mr. Pearce as to the lines which the discussion should follow were altogether too academic and too narrow, inasmuch as he scarcely indicated to us his own ideas and suggestions as to what definite steps should be taken now, and I take it that this is the all-important point, "now," to meet the conditions which will certainly arise on the declaration of peace. If we do not make our preparations immediately, and have general schemes, either on hand, or well prepared to start, then I venture to think the opportunity will pass, and we shall slowly drift back again to the old order of things. Research workers, radiologists, physicists, the Government, and so on are all very well, and can no doubt do something in their own ways to help; but these are not the crux of the question. The manufacturers are the important item. What are they going to do? Everything, to my mind, will depend upon the action that they take, and unless they tackle the question boldly and in a large way, any subsidiary assistance they may get from others will be of little or no use.

I propose, therefore, in order to re-open this discussion on what I consider the main lines of importance, to indicate my own views as to certain steps in organization, etc., which must be taken.

I am merely a professional man, and cannot naturally presume to speak in a dogmatic manner to business men who must know better than I do, but at the same time I am going to venture to lay down some principles on which action should be taken.

I will take my points seriatim:—

There must be an amalgamation of manufacturing interests. Our present X-ray firms are

small, far too small, to offer any chance of success, when competing with the large concerns found in Germany and America. It is only by having a large output in any possible line that it will be possible to sell in competition and yet make fair profit. Our British firms as at present constituted *may* be large enough for the purely home market—if they are out to keep this—but they will not even keep this unless they are able to capture the trade of our own colonies and some of the trade of foreign countries.

I should take this personally to be the very first, and the most important, of all the efforts which should be made for the future of the British X-ray industry. The amalgamation of distributing firms and small manufacturing firms for the purpose of starting great central workshops for the further purpose of the supply of the goods required.

This leads me to my second point, one which goes hand in hand with the first and cannot be altogether separated from it. This point is the "standardization" of apparatus.

Let me illustrate this. Take up instrument makers' catalogues and you will find in many of them a remarkable resemblance in the pictures of, and the prices of, a well-known wooden tube stand. Each firm manufactures for itself what is practically the same thing, but which has some slight modification in construction which enables the said firm to label it with a distinctive name. You can repeat this over and over again with other parts of X-ray apparatus *ad nauseam*. It is a wasteful method of manufacture. Each of these pieces of apparatus which can be with advantage standardized should be; made in one great workshop they could be more easily turned out in quantity by a smaller staff; the cost of production would be less; the advantages for trade obvious.

Some may say that a system of this kind would tend to suppress advance, and individual ingenuity. This should not be a necessity if the manufacturing was carried on in a scientific manner, and on the lines of always striving after improvement. The larger the firm the better should it be able to finance experimental work, to employ research workers, and to employ experts to test the practical value of their apparatus.

Tube making I consider especially is an object lesson in how not to do things. I turn up the catalogue of one of the London firms of instrument makers. I count seventy-six different tubes as listed. I count eighteen different kinds of valve tubes; and this is a by no means complete list of all the different varieties of tubes on the market.

Every practical X-ray worker whose opinion is worth anything could reduce this list to say, half a dozen tubes, and two or three valve tubes. Personally, I should not object to reducing it to, say, three varieties of tubes and no valve tubes at all. You may suggest that to do without valve tubes is impossible; I do not agree. It is possible if makers only supplied apparatus—and it can be done—which does away with the necessity for valve tubes. A re-organization of the industry so that standardization of apparatus and manufacture of tubes went hand in hand, and so that the very best form of X-ray machine (coil or transformer) was combined with the best form of tube, would go far to lessen expense of production, to put a really workable instrumentation in the hands of medical men, and incidentally to improve X-ray work.

Having dealt with these two points I now pass on to others—others which I consider subsidiary, but at the same time helpful and necessary.

(a) Of these research work is of great importance and it is up against manufacturers to point out to research workers the lines on which improvement is desirable. I do not refer so much to the actual discovery of new instruments and new methods, but rather to the improvement of existing instruments and so on.

Expert workers are in a position to know the limitations and faults of the instruments they have to use; they are able to point out where alterations and improvements are desirable. Coils, transformers, and tubes have all undergone vast changes since the early days of X-ray work, but still seem to me to be capable of vast improvement still.

It is research workers, experimentalists, physicists and others, to whom we must of necessity look for work in this direction. They alone are equipped with the laboratory training which is essential for working out the problems of advance. They have a right to expect from the manufacturers, the business men, financial aid in their endeavours.

(b) Further, what assistance can the average X-ray worker give in this national effort ? He, or they, can do a great deal. Up to the present his teaching, or rather, his want of teaching, has been a tremendous drawback to any assistance he can give.

There are a certain number, very few in reality, of sound, well-informed radiologists in this country. The very large number of men who use X-ray apparatus know little or nothing about it, or about the work they attempt to do with it.

It is necessary that the education of radiologists from the technical point of view should not only be possible, but should be insisted upon. I have not the slightest doubt but that in the future every medical student, before he qualifies, will have to imbibe some knowledge of X-ray work and its possibilities, and further, that every one specializing in this branch of medical work will have to attend post-graduate courses of instruction and pass a special qualifying examination on the lines of, for example, the D.P.H., or of the diploma in Tropical Medicine.

This means that the present is the time for the teachers in this country to organize teaching and press the claims to due recognition of their speciality.

Indirectly this teaching will have its effect on the X-ray industry, as the men demanding and using apparatus will know what is required and what they want.

At present the man contemplating X-ray work does not know either what is required or what he wants, and this leads to all sorts of anomalies in equipment.

Look at another catalogue, and you will find a description of about twenty more or less elaborate pieces of apparatus for the localization of foreign bodies, and in addition innumerable bits of apparatus recommended as convenient and suitable for assistance in this work.

Anything more absurd, and more cumbersome, and more costly than most of them, for doing what can be done with equal precision by the simplest of apparatus, it is impossible to conceive. The expense of manufacture of most of this stuff cannot possibly allow of a fair return of profit to the makers. It is not by putting all this senseless variety of apparatus upon the market that you are going to capture the X-ray trade. Ignorance of what is required, and the desire to see one's name attached to some pretty picture in a catalogue, is responsible for much of this kind of thing, and it is a pity that manufacturers pander to the latter desire.

Mr. Wright was responsible for the suggestion that a feeling should be created amongst British subjects to buy British-made goods. I agree. But how can this be best brought about ? Not by present methods and the study of these elaborate catalogues. The essential thing is, of course, that British goods should be as good as, if not better, than any made anywhere else. Also that they should be the most suitable for the work which they have to do.

What happens now, and what has happened in the past, if you wish to see the apparatus of different firms ? You go to the show rooms and are shown odd bits of all sorts of things—interesting in their way no doubt. But, if I were running the show, I would see to it that if anyone came to inspect my apparatus he should see in a show-room not a collection of oddments, but he should see rooms with complete installations set up, which were in working order, and where competent demonstrators could then and there demonstrate the actual working from first to last.

It would cost money, no doubt, but good apparatus set up in this way would be very convincing. Amalgamate your interests and the thing could be done.

The next point is "Protection." By this I take it is meant crudely a tariff on goods coming into this country from other countries. It is a sharp-edged sword, probably sharp on both

edges. If by it you manufacturers think to bolster up inefficient goods, it won't work. Nothing will keep out better and more efficient apparatus; and the user will pay the extra for the best stuff. If, on the other hand, it is meant by it to put a stop to, or at any rate a drag on unfair methods of competition, then it may be of use. I do not feel competent to discuss the pros and cons of this as a means to establish and protect the future of the British X-ray industry, but carefully used it appears to me that it may be of assistance. Others must decide this point and its application.

Finally, I come to what, in my opinion, after, or with, my first point, namely, amalgamation of manufacturing interests plus standardization, is the second great problem for the future. This is the British working man and his relation to so-called capitalists and capital. He has had much unfair treatment in the past, can one wonder if with the knowledge of his power at the present time he is apt to use this ill-advisedly?

I have a strong feeling that not enough is being done to attempt to bring about a better understanding between capital and labour. The two are by no means antagonistic, or at any rate should not be.

The working man wants to be taken more into the confidence of his employers. At the present time he is left too much to his own devices and to the leaders who foster his antagonistic feeling and who make capital out of the cry of Capital *v.* Labour. Who ever hears of employers, or the representatives of employers, addressing their own men on the subject of their business? If I was an employer of labour I should make it my business to consult with my men. I should explain to them my objects, I should explain to them my difficulties, I should try and make them understand that they were part and parcel of a going concern which would be carried on, not only from the point of view of the profit I was trying to make, but also from the point of view of the living they were going to make out of it. The British working man is no fool, but at present he only sees one side of the question and no attempt is being made that he shall see the other.

Take a man like Sir Wm. Lever as an example of a great capitalist, and a man I suppose who would be held up to the British working man as a typical example of one who has flourished on the work of others and who has no right to the enormous fortune he has made. Rather I take it he is an example of the kind of man who, as long as his workpeople get a fair return for their labour, is an asset to the nation and to the working man. He is a creator of work, and by his brains alone has brought untold riches to this country, riches which have by no means gone to himself alone. His trade is with the world, and for every million he makes for himself how many millions have gone into the pockets of the working men, and how much wealth has been added to the nation? I am afraid when the working man cries out about the conflict between Capital and Labour he does not see this side of the question.

This country is at the parting of the ways. We are up against a big—a tremendous—proposition. Our life as a nation, and this applies equally to the so-called capitalists and to the British working men, depends upon conjoint, well-considered action in the future, upon a combination which, if used in the interests of both and of the nation generally, will mean our pre-eminence in trade for many a long day to come.

We stand on the threshold of a great opportunity and it behoves us all to see that this opportunity is not allowed to slip from our grasp.

Internecine strife, capital *v.* labour, and we inevitably fall. Trade cannot exist without capital, and capitalists are those who have the brains to finance trade; capital cannot exist without labour, and it behoves capitalists to see that labour works under proper conditions of housing and living and has its fair share of the proceeds of success; whilst labour must, in its own interest, for its own life, see that trade is not hampered by stupid and short-sighted regulations, and that for a fair share of the profits a fair share of honest work is done.

The future of trade is in the hands of both employers and workmen in equal shares. Neither can exist alone, and trade cannot exist without

both. Big combinations must necessarily be the feature of the future, and the worst of companies—in contradistinction to individual employers—is their want of heart. I am a great believer in the British working man. He has had, and is still having, a big struggle for his just rights, good food, good housing, good education, and the right to live a clean, healthy, independent life for himself and his family. Give him all these, see that he is treated as an equal in this great national concern of ours—and I have no doubt but that he will give the work—the honest and best work—of any worker in the world.

Dr. J. METCALFE said : I have listened with the very greatest interest to this discussion in connection with the future of the X-ray industry. Mr. Pearce in his opening paper gave us a lucid exposition of the state of the industry previous to the war, but he made no very concrete suggestions as to what should be done to remedy the defects. I have known Mr. Pearce for a very long time—I should think for the last fifteen years—and I have always found him a man of the utmost geniality and of the greatest competence, and the remarks he made on the last occasion were very much to the point. But he acknowledged—and we all know—that the industry in this country was in a very backward way when the war started, and Professor Porter told us that England was waking up, that indeed it had awakened and that we intended to do something much better in future. Then, if it takes a war to wake us up, what was wrong with us ? There must have been something seriously wrong in our body politic if it has taken a great war like this to waken up this industry. Up to the time of our President's remarks this evening, I do not think that any reflections have been made upon the manufacturers of the X-ray industry taken as a body, but, as the President said, one of the manufacturers, Mr. Wright, made a somewhat laboured but very strenuous attack on the medical profession in connection with this work. I do not want to make too much of Mr. Wright's remarks, but I only wish to draw your attention to the fact that if the idea that the medical profession were at fault is regarded by the manufacturers of these instruments to have been one of the chief reasons for the X-ray industry being in the decadent condition it was previous to the war, then we may say good-bye to any hope of improvement in the future. I would say to the manufacturers : You will have to look into your own defects a little more than into the defects of the poor doctors. The doctors previous to the war had to roam over Europe in order to get what they wanted. Mr. Wright thought they always went to Germany ; we went to the place where we could get the best instruments constructed so as to be able to do the best we could for our patients. And that is always the end and aim of the medical profession. We can admit no special advantage for British-made workmanship unless that workmanship is as good as or better than that made by foreigners—it does not matter whether those foreigners were French or German or Austrian. This matter is very important to us from the curative point of view, and we must not be carried away by the idea that we are to favour an industry which is not keeping up to the mark. We must get the best things for the treatment of our patients, and in order to do this before the war we had to go abroad for many of our instruments. Mr. Andrews spoke of an X-ray tube being a globe of glass surrounded by profanity. But there are degrees of profanity. Before this war the use of the British X-ray tube produced such a degree of profanity that really one was afraid for one's immortal soul. A great many other instruments were of a similar character. We got our intensifying screens, our tube stands, our screening stands, our tungsten anticathodes and things of that kind from abroad. Up to the period of the war, and indeed up to quite recently, our manufacturers even went abroad for the bulbs of glass they made the X-ray tubes with. Why should we have gone to Germany and bought German glass for these X-ray tubes ? It was surely possible to have started some original work much earlier if only there had been enterprise enough.

Then there is Mr. Wright's Snook story. The President has said that the Snook apparatus is a most admirable one; it has worked extremely well—I do not know whether he got that apparatus when it was manufactured by Mr. Wright, or got it directly from America—but I have used an apparatus of that character for the last four years. I think the apparatus is an excellent one; it is an excellent one now, and I have always liked it, but it has had the unfortunate habit in my hands of breaking down on many occasions, and, talk about profanity, it certainly produced such an amount of profanity that would even have upset Mr. Andrews! Now, during the same period, I have also used a large foreign—German—transformer. I have not had one breakdown with it during the last four or five years. I have had no trouble whatever; I have hardly had to oil the machine, and it has never gone out of order. It may have been partly luck, and I am casting no reflection upon Mr. Wright's Snook at the present moment, but what I say is that up to the period of the war the apparatus was not so certain in its use as it might have been. It was an expensive apparatus too, and naturally doctors reflected very considerably before they expended several hundreds of pounds in buying an apparatus of that character.

To return to the lack of enterprise shown by the British manufacturer, I am not speaking of the X-ray industry alone, but more or less of industry generally. Although I am a professional man, for many years I lived in a great industrial centre in the North of England and came a good deal in contact with industrial work, and the laxity of initiative there was, in some of those great industries really extraordinary. I recall a statement made by Professor Dewar some years ago at the Royal Institution. He stated that when he invented the "Thermos" flask, he could not get a British manufacturer to make it; he went to Germany, and the Germans took all the kudos for manufacturing that instrument which has been of the greatest benefit to civilization. I happen to know a great linguist, a man who has travelled everywhere, and who has a profound knowledge of commerce. He went abroad as a representative of a great firm of oil and paint manufacturers in Wolverhampton which had been established for the last 140 years. He went to every country on the globe—particularly to South America and to our colonies. He offered paints and varnishes. "Oh," he was told, "but we can buy it from a German firm at £1 a hundredweight less than that." He pointed out that the product of the German firm would not last. "But we don't want it to last," they said, "we want our houses repainted frequently, so that they always look nice and bright." He had to say that he was very sorry, but his people would not make common stuff. They would not make it, and consequently no business was done. It is this stupid obstinacy that is found so often in British industries—the refusal to give a client what he desires to have, because it does not accord with what the firm thinks would be the best for him—which has been the bane of English commercial life. I have not the least hesitation in saying that.

Now, with regard to this question of our own industry. It seems to me, sir, that the trouble has not been in the initial stage of invention and research. We have had men of great eminence who have been masters in research—men who have been carrying out experiments in every direction. There is no need for better men. Also with the examples of men like Sir James Mackenzie Davidson and our President, it is evident that the doctors have not been found wanting. They have done their best, carried out their work well, and are able to hold their own in any part of the world. But there has been a hiatus somewhere. Nor do we need reform in the quality of our workmanship. I think that the English manufacturer makes undoubtedly the best material in the world. No man can beat him in manufacturing things if he wishes to manufacture them. But there is want of initiative in constructional work, and it seems to me that that is to be remedied largely by a better technical education of assistants and apprentices employed in the industry. If you gentlemen who are connected with this

industry would assist in founding a department in one or several of the technical colleges in the country, and see that your assistants and apprentices attended there in the evenings and got some idea, if not actually of research, of the best class of constructional work, you would do a very great deal towards helping on the work you have in hand.

Those are the points which seem to me of the very greatest importance, but other points have been brought forward, such as the co-ordination of manufacturers. I hardly think it feasible in an industry of this character for all the manufacturers to combine together ; there must always be a certain amount of feeling that a man wants to stick to his own business, but I think there might be co-ordination in connection with the technical college and also with the scientific men who are carrying on the research work. If some movement of that kind could be originated, undoubtedly you would be able to do good work. Then, again, there are other things to be considered. The President has mentioned the matter of preferential tariff. Mr. Wright asked if we were prepared to sacrifice 10 per cent. in order to get British-made goods. That is not the point, sir. The point is: are you prepared to give us as good as or better instruments than any other manufacturers in the world ? You can do it if you try. But if the Germans after the war attempt to throw their sweated goods into this country, then I think you have a right to some restrictive tariff in order that they should not undersell your labour. That would be a right and proper tariff, and one that ought to be carried out. Then, again, there is this question of enterprise and initiative and the capacity for seeing things from the customer's point of view. One gentleman who has struck me with his enterprise has all his catalogues printed in both French and English, and I think that in the future the thing to do, if you want to establish a world-wide industry, is always to have your catalogues printed not only in the language of the country with which you hope to deal, but also to use the weights and measures of that country and its forms of currency. It is remarkable how Englishmen neglect to do that. I have known large firms in this country who thought it derogatory to print their catalogues in any language save English or to use any other weights and measures than our own. If these points are attended to—a technical institute, co-ordination between different bodies, and catalogue "proselytizing"—I am quite sure that, your work being the best in the world, the future of the industry will be a great and a lucrative one.

Mr. P. J. NEATE : A good deal was said at the last meeting as to the difference in the attitude taken up by medical men and buyers generally in Germany and in England. Comparing the spirit of professional men and committees in England with that of their German compeers, I think I may boil it down to the statement that the German is patriotic all the time, but the Englishman is only patriotic when he is "riled" or stimulated. Rarely, indeed, does such patriotism extend to daily shopping or to the examination of competitive tenders. The thoughtful German welcomes a tariff which will compel the unpatriotic or thoughtless buyer to follow his example. The Englishman, on the contrary, normally does little but "gas" about the liberty of the subject, and buy in the cheapest market. We have had in the past no British equivalent for *Deutschland über Alles*. What will the future bring unless Parliament be converted to lead the way ?

Mr. Pearce concluded his able and interesting paper by putting some questions. To these I would reply as follows: Commercial remedies for the present condition of things are tariff reform (in spite of Professor Porter), combination and standardization. By combination I mean not so much amalgamation as a co-operation in order to assist standardization of manufacture, so that one firm shall make one article and a second firm another article to dovetail into the first. In that way rapid construction is possible, as the enormous output of munitions has lately demonstrated. Scientific remedies are the establishment of central research institutes with very able chiefs, supported by individual

outside helpers, willing to give freely, *pro bono publico*, in cash, brains, experience, or time, according to which predominates. There should be frank disclosure to this central institute of minor discoveries, failures, and needs; also a recognised journal edited at the central institute and supported by the trade both by communications and advertisements (the latter to the exclusion of all other forms of advertising except trade circulars). Another very necessary condition is active support of more equitable patent legislation, especially in limiting the rights of foreign patentees to the rights given to British patentees in their country. Yet another is the extension of the foreign origins marks legislation so as to cover parts as well as aggregates.

In conclusion, I will just give a tip to which I owe not a little of my small success as an engineer. I always paid special attention to my customer's scrap heaps, on the principle that, however successful a machine might be, that was no positive indication that it might not be better. Every ounce on that scrap heap told a tale of failure—definite, positive, and capable of rectification. Therein lay the road to useful research.

We were bidden at the last meeting to remember the story of the man whose applecart was upset and for whom the hat went round. Well, sir, I think that if the manufacturers sent the hat round among themselves and put three months' profits in that hat, and then came to the city companies or the Government and asked them to give a hand, something definite and substantial would be done. I mention the city companies because at the present time the Leeds wool industry is being very largely assisted by one of them, but it is a *sine qua non* of such assistance that manufacturers guarantee to provide funds and information for such research, and when they have got their plans all organized, on paper, they get additional and substantial help from the University of Leeds out of funds provided by the city company. The great point is for users and manufacturers to be frank with each other, state their difficulties, and disclose their secrets as far as may be possible.

Mr. W. F. HIGGINS: The question of research laboratories has been discussed by several speakers, but a point that has been overlooked is the establishment of small laboratories attached to each works for the control of the firm's manufactures. A good deal could be done in the way of standardization of materials if such control laboratories were actually brought into being. I believe some firms do a small amount of experimental work in connection with their manufacture, but it is desirable to have it taken up on a larger scale. A suitably equipped laboratory could be installed at a relatively small cost. There is also another point worthy of consideration in this discussion. So far the medical aspects of X-rays in relation to this subject have been dealt with almost exclusively. But X-rays may have other applications of usefulness which it might be well for the industry not to disregard. There is, for instance, the examination of metals by means of X-rays—a very promising field, but the apparatus required, including the coils and the transformers and tubes, will have to be specially designed for that work. The ordinary induction coil, etc., will not furnish rays sufficiently penetrating. It would be necessary to have tubes which would stand such a pressure as that indicated by a 15 in. spark gap. There are various other directions in which X-rays could be usefully employed in the engineering industry. Engineering manufacturers are in a large number of cases people who could afford big sums for equipment, and it should be a very useful field, especially in view of the fact that there will be a large drop in the purely medical demand for X-ray apparatus after the war. That demand is at its maximum at the present time. All the large hospitals necessarily have been ordering big installations, and for some years to come it is very unlikely that large additions to equipment will be required. Therefore new fields must be looked for. I believe that cigars are treated by X-rays in order to kill certain bacteria that are present. This is just a small example, but it shows that it is commercially possible to apply X-rays to subjects other than medical and it is worthy of the attention of the industry

generally in order to go into the matter a little more fully.

Mr. A. E. DEAN: In answer to the questions which Mr. Pearce set out at the close of his paper, I would say that the competition was such that the German importations swamped home goods and home designs and imposed on us their science and nearly reduced us to a state of anæmia, and to-day we still find radiologists looking through German spectacles.

We find, even in a catalogue for which Mr. Pearce is responsible, the Levy-Dorn and Albers Schoneberg, the Krunicholz tube box and other apparatus bearing German names.

I am not with Mr. Pearce in attributing the parentage of electrolytic rectifiers to Kock and Stertzel, of Dresden. Nodon, of Paris, was the originator and the prototype of the Snook was undoubtedly D'Arsonval, who rectified high frequency by means of Villard rectifiers, and the real inventor of the Morton rectifier was Ropiquet. But I am with Mr. Pearce when he says single-flash apparatus has not been seriously tackled here and the reason is, I believe, that so few would entertain the cost if it were produced, and this fact is again answered that there were no medical funds for untried freak apparatus; few hospital committees and medical men would or could entertain the question. This pernicious long credit system enabled Germany to penetrate all the countries of Central Europe, and east of the Rhine, virtually nothing is known of western radiology. Yet there does exist a French School, a British School and an American School. In spite of the fact that German production was "kolossal" very few of their firms made money, on the contrary, they often brought a deal of litigation on their shoulders and I am told that there were about fifty cases down for hearing in the Russian Courts for goods not being up to specification and this referred largely to a certain popular interrupterless machine.

I was much interested at the description of Mr. Wright's patriotic flit to Amsterdam after Mr. Clyde Snook. I also went to Amsterdam, but when I got there the Snook machine was packed up, but there was on show in a side room the "Ideal Interrupterless," which was not shown the light of day until the American had gone. But it was there and was shown to a select few and was disposed of to a Dutchman.

The facilities of the German post and their central position put them in a most advantageous position, but this was not sufficient explanation in itself of the cause of the pre-war situation. It was the clinics of Vienna, Berlin, Freiburg and Hamburg that produced the acolites of German radiology, and it is here that Britain has been lacking and this is a stone in for medical gardens.

It is not my intention to throw stones in any garden or certainly much glass might be broken. The academicals, the medicals and the technicals have all been found wanting in the very element which has made the German school so formidable, and that is "Chauvinism."

There has been no concerted effort to create a British School of Radiology. I would not say that the academicals have not contributed their share to the science; they have contributed largely, but do they realize when they are talking shop which is generally in the terms of the tenth power of N? How far over the heads of the medicals and technicals they soar, and so render their contribution almost sterile. This must not be taken as a reproach, but as a reminder that the busy medical and the struggling technical have not the time or the ability to raise themselves to the field of higher mathematics. If the academicals would come down from their exalted level and the technicals come up a bit we might then make a start with the job of providing the British Empire with a school of British radiology, and there is no better common ground than the British Röntgen Society, and I would suggest that a strong committee be formed to elaborate ways and means for laying the foundation for this need. I would like to remind you, that there are still the embers of a British school. Britain has shown the way in a few things and perhaps nowhere so strongly as in the means of protection. The British methods of protecting radiologists are appreciated by France and America and South America and Japan. When

the number of victims was at its highest the London Hospitals was faced with the problem of providing protection for its staff or relinquishing X-rays. What did they do? They asked for a scheme, if such were forthcoming, and boldly found what was then a big sum of money to provide four X-ray proof cubicles, which served as a prototype for the whole world, and I think we owe a debt of gratitude to Lord Knutsford and his colleagues who voted the money and showed the way.

This was followed by other important general hospitals in London and the provinces, and I think the menace to the permanent staff was harnessed from that date. Although I have been personally associated with providing many of these protective schemes I think we have not done justice to the very original scheme suggested by Dr. Lyster at the Middlesex Hospital, and were we to continue to receive such Chauvinistic support we should soon get British Radiology on a solid foundation. In this connection it is regrettable to state that the X-ray Committee of the War Office, without a technical member on it, have turned down a glass shield with a density of 4 produced after a formula provided by Prof. Herbert Jackson, preferring in its place a rubber composition. It is this sort of thing which throws cold water on the few good British innovations.

And in this connection I would add that not only the War Office, but other committees have also not played the game. In one case I was asked to collaborate with an architect to prepare plans for building protective cubicles. This I willingly did, giving him the advantage of my experience, but the committee afterwards gave the job to a rival who filled the hospital with German Kultur.

Now how does British Radiology find itself to-day cut off from its spiritual home? Has it succumbed to pernicious anæmia? Has the work suffered? Have the Tommies suffered? I think not. I have never seen finer work in any of Berlin, Vienna, Hamburg, Freiburg hospitals than that produced in some of the clearing hospitals in France. Where did the apparatus come from to satisfy the enormous army demand? From the works of the insignificant little British manufacturer. It is in field ambulances, casualty clearing stations, base hospitals, war hospitals and hospital ships. *It is often abused, very often misused by aspiring amateurs and aspiring experts*, but it is carrying on and the job is being done. Having proved that we can do useful work let us put our house in order and endeavour by combined effort to do brilliant work—and, gentlemen, the keynote is not protective tariffs nor state aid, but Chauvinism. Let us lay our cards on the table, inaugurate a War Exhibition of British Radiology. Let the medicals tell us where we fall short and the academicals tell us in plain language how to put it right. Then we shall be doing good to British radiology and incidentally to ourselves.

Mr. B. H. MORPHY said: I have to congratulate Mr. Pearce on raising a subject which is of such vital importance to everybody not only to the manufacturers, not only to the doctors of Great Britain and every country which may be supplied by our manufacturers, but also to the patients of those doctors, and this includes practically the whole population.

I think it is hardly realized how vitally the improvement of X-ray apparatus methods affects the man in the street. Without treading on the toes of the medical profession, I think I may safely assert that many cases might with advantage be examined under X-rays that, owing to one cause or another, do not come before the X-ray tube at the present time.

From one speaker and another we have had various destructive criticism, but up to the present there has been very little constructive beyond the broad expression of opinion that some form of co-operation between manufacturers, physicists and doctors is advisable.

It appears that the first step at any rate is to bring about some co-operation of this sort. I should like to suggest that a committee be formed combining representatives of these three classes to thrash the whole matter out and outline the steps that should be taken by this Society. The following subjects, beyond the

one of specific co-operation, require early attention :—

(1) The drawing up of standard specifications for hospital outfits.

(2) Standardization of tests and arrangements for carrying out these tests.

(3) General publicity for X-ray work.

(4) Setting up of an X-ray clinic.

(5) The encouragement of research and publication thereof.

The Röntgen Society is the proper body to carry out this work as it combines all three points of view, that of the doctor, the physicist and the manufacturer, and the subject will therefore not suffer from being treated with the interests of only one section of the community at heart. Between the manufacturers themselves, I am glad to say, there is a little more co-operation than existed even six months ago, and I have great hopes that the Association in which they are all enrolled at the present time will be the means of fostering the industry considerably.

I do not want to speak at any great length, but there are a few points further that I wish to touch on.

Tariff Reform has been referred to by some of the speakers. I do not believe that Tariff Reform by itself will keep our industry in the front rank, but there is no doubt that owing to a scientific tariff the German manufacturers were enabled to avail themselves of a larger field for their goods and therefore were able to manufacture on a large scale. Our manufacturers must be able to manufacture on a large scale if they are to employ scientists and engineers of sufficient capacity to keep our instruments ahead of foreign countries. We shall not gain or keep the trade unless our goods are at least equal to those of our foreign competitors. Individually, we can turn out just as good instruments as any foreigners, but we are not turning these out in a commercial scale and creating a market for them.

The question of research has been referred to many times. In the long run it seems to me any firm which is to be in the forefront must have its own research laboratory. This means that firms must be considerably larger than those existing over here at the present time. As a great many different branches have come in for their share of blame I think we should also look to our own Society and see whether that is quite free from any faults of omission or commission. I am of opinion that a great deal could be done by this Society if it were really energetically worked with the specific view of advancing X-ray work generally in all directions, manufacture, technique, publicity, etc., etc. Every doctor who uses X-rays should be a member of this Society. The attendance at our meetings is not in any way proportionate to the work that is being done with X-rays throughout the country. What is the reason ? It should not be beyond an energetic committee to better these conditions. Some of the speakers have laid the blame on the doctors, some on the manufacturers. There are faults on both sides and instead of recriminating it is more advisable for us to get together and decide how these faults can be avoided in the future. I am sure we can rely on the patriotism of the English doctors not to purchase German apparatus in the future unless they are very sincerely convinced that it is advisable on behalf of their patients.

As regards the manufacturers, it is up to them to prove that their apparatus is the best that can be produced. Great strides have been made during the last few years, and there is no reason why improvement should not continue, provided we all pull together and do not waste our energies on internal warfare, but concentrate on producing articles to beat all foreign manufacturers.

Mr. W. E. SCHALL said : When we compare the position of the X-ray and electro-medical industry in England before the war and now we have, I think, every reason to be proud of the way in which the strain and demand have been met. The number and size of the factories engaged on this work were small and much of the experience which continental and American firms had been able to accumulate during the course of years, had to be gained by British firms during the course of months.

It must be obvious that the times ahead are bound to be serious for the industry. Two factors, namely, the universal lack of money and the large quantity of available second-hand apparatus, are bound to affect it and will materially reduce the number of new apparatus produced.

I do not think that we need fear the question of foreign competition in the United Kingdom very much for some years, for the following reasons. There are four countries who occupy themselves with this work, and they are America, Austria, France and Germany. Of these Germany and Austria cannot take up a position of prominent competition for several years owing to national feelings against them and also to possible prohibition to import.

French firms will, I take it, endeavour to compete in the British market, but I do not anticipate that their efforts will be as serious as those of America.

American firms will certainly compete, and will have some advantages in the form of up-to-date machinery, organization and larger supply of the particular type of skilled labour which is necessary. On the other hand they are, and will be, seriously hampered by the question of freights and times of delivery. Shipping freights are not likely to be reduced for some years nor are the times taken to send consignments from there to here. Consequently we here should be able to compete, and at the same time to give prompter delivery, though this latter point could be overcome by their establishing large depôts here.

But these factors will mitigate against American competition for a time only, and then either freights will have to come down or they can start factories here and work under the same conditions as we, with the addition that they will have the benefit of American research.

There is, however, a more serious form of American or other foreign competition to be met. We have seen that if American firms rely on going to their clients they will find a competition here which will not so easily be overcome. Suppose, however, that the clients go to America, that the American School of Radiology becomes so strong, so famous and presents such advantages to those seeking after knowledge that they go to America. In other words, America can compete by causing the market to go to her, just as Germany before the war attracted radiologists from all countries. This, to my mind, is the greatest danger of all. It is perhaps natural that Canada should go almost exclusively to the States for X-ray supplies, but it is not necessary that Australia, India or even South America should go there.

These considerations brings me to the whole point of my remarks. The most effective, and I would even say the only way to meet competition is that the British School of Radiology and Electro-therapeutics, together with its attendant industry, must achieve a reputation for excellence in all directions, which will cause men from the Colonies and from foreign countries to come and see our work and as a natural sequence to install our apparatus, instead of going to Germany or America with this end in view.

And how is this to be effected? The subject is a very large one. It opens up widely separated lanes of discussion, such as the importance of scientific training, tariff reform, research, and so on.

I propose to deal chiefly with the work which this Society could do in helping to attain this end.

X-ray work is a very specialized branch of physics and medicine, such that the average medical man or physicist, no matter what special qualifications he may have, must needs study the subject carefully and, in fact, learn it before he can either take charge of an X-ray installation or carry out any useful research work. At the present time there is very little facility for instruction other than the reading of books and inspecting equipments, either in manufacturers' show rooms or in hospitals. In Germany before the war the most important firms held courses of lectures on X-ray apparatus and technique at regular intervals in their own lecture theatres. Physicists of their technical staffs dwelt on the construction and management of the apparatus and X-ray specialists lectured on technique. An exact copy of the

system would not be possible here, owing to the different conditions, but I have felt for some time that something very similar might well be carried out under the ægis of this Society, at any rate, unless and until the medical schools and universities take the matter up.

SCHEME OF LECTURES.

I suggest that such courses of lectures should occupy, say, four or five days. There should be about five lectures in all, each lasting about two hours. One should be devoted to a rapid recapitulation of the simple physical laws which are known to medical men from their university curriculum, the second lecture would be devoted to apparatus management, repair and control, the third would deal with the general principles of radiography from the practical point of view, the fourth with therapy, dosage and so on, and the fifth with the more medical side of radiography, such as plate reading, etc.

Of these lectures the first, second and perhaps the third would be in the hands of physicists, whereas the fourth and fifth would be delivered by medical men. Finally, there would be one or two afternoons devoted to practical radiography and radiotherapy.

And may I throw in a remark here in connection with that first lecture on physics? I speak absolutely as a layman when I refer to the curriculum of the medical student, but I speak as a layman who has had some little opportunities of observation. It seems to me that if the study of physics were given more importance than is actually the case, the future medical man would benefit, not only when facing an X-ray plant, but also in all electro-therapeutic work and in much other work which is in some way or another based on the elementary laws of physics.

In this way the idea would no longer be so prevalent that radiography is merely a specialized form of photography and that all that is necessary is to turn the handle of the machine, and the condition of things with which our President dealt in his address in October would be considerably ameliorated.

The Society could surely arrange for space wherein to deliver these lectures without much trouble or expense, and again it should be possible to find lecturers among the members who would undertake the work as a labour of love, and finally the necessary apparatus would most certainly be lent gladly by manufacturers.

A start could be made in this way, and we should very soon see in what direction the next step lies. One's imagination carries one forward to times when out of this small beginning an annual congress of X-ray workers will have developed, similar perhaps to that mentioned by Mr. Pearce, and attracting workers from all over the Empire.

I should, however, expect the greatest results of such teaching of the physics and technique of radiology from the impetus which it would give to original work. We are, I think, far too ready to imagine that all that is necessary to stimulate research is to set up a well-equipped laboratory. Now in the first place—who is to do this on a large scale? Individual firms cannot because when all is said and done, the demand for X-ray apparatus does not warrant the laying down of so much capital, or the employing of a man engaged on nothing else than X-ray research. It is all very well to look at firms like the Eastman Kodak Co., of Rochester, or the General Electric Co., of Schenectady, but we must remember that their laboratories are not engaged solely on X-ray research. In the one case the whole subject of the dry plate and film industry for every conceivable purpose comes within the scope of the laboratory's work, and in the other case the whole question of electric lighting with all its ramifications is dealt with.

We must, I think, rely far more on the individual efforts of medical men and technical men. And we must absolutely free our minds of the idea that research or merely an improvement of apparatus efficiency can be rushed. Such results as have from time to time been published are the fruit of long, persistent work on the part of minds driven, less by any thought of ultimate gain, than by a desire for knowledge, by a wish to push the boundaries of science still further into the unknown. And though it is

often or even generally possible to say roughly at the start what the course of a research will be, it is quite impossible to predict what discoveries, what improvements more important perhaps than the whole object of the research will come to light during its progress. A classical instance, of course, is the very discovery which gave birth to this Society, and such work can, I submit, be stimulated by the existence of facilities for learning the elementary and the more advanced theory and practice of X-ray work.

We should, I think, find after a while that more original work was being done and more was being published. And in this connection I can but express the hope again that this Society would become the medium of publication to such an extent that it would be possible to hold annual X-ray congresses on a scale comparable to those abroad, which would attract X-ray workers from overseas.

The thoughts which I have expressed here in a brief and perhaps sketchy way are to me the only sure way of establishing a great X-ray industry. A flourishing industry must be the servant of a strong and productive school of radiology and the first step to take in this direction is to give facilities for study of the phenomena employed.

Let us have no doubt that this work is a big labour and a labour of love to a large extent, and that much time must elapse before one can point to definite results, but let us also be sure that once the British School of Radiology has become a respected entity whose work is studied and advice sought, the British X-ray industry will stand so firmly on its own legs that it need not fear foreign competition, no matter whether tariffs and prohibitions exist or not and that it will produce its own patterns and inventions, instead of relying largely on what is done abroad. And conversely an X-ray industry which is not connected with a school of radiology—productive of ideas, of inventions and of sound work will not flourish, no matter how high a tariff or how stringent a prohibition to import is placed all round it.

There are only two other points in the discussion this evening upon which I would like to touch. The catalogue which was referred to by a previous speaker (Mr. Dean) was, of course, published before the war broke out, and therefore the names which appear in it belong to the time of peace and not to that of war. Then I should like to thank the President for his remarks. His idea of capital and labour discussing the problems of business opens up a prospect much more hopeful than that which appeared before us on the last occasion.

The PRESIDENT, who remarked that efforts were already on foot to start a British School of Radiology in this country, announced that the discussion would be adjourned to the June meeting of the Society, when it would be reopened by Captain Knox.

NOTES.

A PAPER on the Germicidal Action of Ultra-violet Radiation and its Correlation with Selective Absorption, by C. H. Browning, M.D., and Sidney Russ, D.Sc., was read before the Royal Society on Apr.l 26th, of which the following is a short abstract :—

1. A new method is described which renders it possible to determine what portion of the ultra-violet spectrum is most effective in germicidal action and, further, to specify the wave-length of the radiation at which such action practically ceases.

The method consists in exposing a thin film of organisms spread on a nutrient surface, such as gelatine or agar, to the spectrum from a tungsten arc. The image of the slit of the quartz spectrometer used produces a permanent effect upon the bacterial film over a certain range of wave-lengths. This germicidal action becomes apparent on incubation at 37 deg. C. subsequent to the exposure ; thus a copious growth occurs except in those regions where the organisms have been killed. Records of such action are obtained which resemble a photograph of the spectral lines.

2. The method has been applied to test the range of susceptibility of a number of different pathogenic organisms. By the process described it is possible to expose cultures of two different organisms simultaneously to the same intensity and character of radiation. The ranges of susceptibility of *B. typhosus* and *B. coli* are closely similar and practically the same as those of organisms, such as staphylococcus pyogenes aureus and the meningococcus.

3. A striking feature of the germicidal action of the radiation in question is its abrupt termination at a wave-length of about 2960 Å.U.

4. It has been possible to correlate this feature with "selective absorption," for it is found that the organisms exhibit marked absorptive power for just those rays which have germicidal action.

AT the same meeting a paper was read by G. W. C. Kaye, D.Sc., on "The Composition of the X-rays from Various Metals." The X-rays from a bulb excited by low voltages (10,000 to 50,000 volts) are rich in the

characteristic radiation of the anticathode. In the case of iron, nickel and copper the amount of K-radiation lies between 80 and 90 per cent. In the case of platinum the proportion of L-radiation is from 40 to 60 per cent. Evidence of characteristic radiations softer than the K or L radiations has been obtained.

THE PHYSICAL SOCIETY OF LONDON.

"The Absorption of Gases by Quartz Bulbs," by Dr. R. S. Willows, M.A., and H. Trevelyan George, M.A.

The experiments are a continuation of those of Willows ("Phil. Mag., April, 1901) and Hill ("Phys. Soc.," December, 1912) on the absorption of gas which is brought about by electrical discharges. A new quartz bulb does not absorb air, but if it be fed with repeated doses of hydrogen—which are absorbed when an electrodeless discharge is passed—it then becomes very active. If discharges in hydrogen are alternated with those in air the bulb can be made to absorb large quantities of either gas, and the activity with each gradually increases. The authors reject the theory of surface absorption and, in their own experiments at least, also Swinton's theory that the gas is shot into the walls and held there. It is supposed that chemical actions occur with air, and oxidation products are formed; these are reduced by hydrogen. The process is compared with the formation of the plates in a Planté cell; the absorption of hydrogen corresponding to the charging, and that of air to the discharging of the cell. Attempts to produce the same effects by chemical treatment are partially successful, particularly in fatiguing the bulb so that no further absorption takes place. The conditions under which the primary and secondary hydrogen spectra appear are also described.

At a meeting of the same Society on May 25th, Messrs. C. C. Paterson, J. W. T. Walsh and W. F. Higgins communicated the results of an investigation upon Radium Luminous Compounds.

The paper gives measurements made on various samples of radium luminous compounds during the last two years. Determinations of the brightness in powder form and when made up into paint, and also after the application of the paint to instrument dials, were carried out; and curves are given showing the rates of decay of luminosity. The radium contents of the compounds were determined by comparison of their γ-ray activities with that of a preparation of pure radium bromide, which is periodically compared with the British radium standard. Various precautions have to be observed, and the corrections which have to be applied in making the various determinations are explained, and the considerations which should govern the proportion of radium employed for practical purposes are discussed.

SMALL COOLIDGE TUBE.

The British Thomson-Houston Co., Ltd., have placed upon the market a special tube for fluoroscopic and radiographic work. The bulb is 3¾ inch in diameter and the focus spot is made as small as possible, which should improve the definition—the tube works with currents up to 20 milliampères. The price is £27 10s.

SOME NOTES ON DEVELOPMENT.

Messrs. Elliott and Sons, the makers of the Barnet X-ray plate, have issued a small booklet on the above subject. The notes are so "common sense" and valuable that we would strongly advise operators to apply for a copy. But for want of space we should reprint it in full. The following summary at the end of the booklet is worth careful consideration. Ask youself these questions.

Was the exposure correct?
Are your dishes chemically clean?
Is your developer right?
Do you flood the plate evenly?
Do you use thermometers?
Is the hypo solution fresh?
Do you fix in a tank?
Do your plates dry evenly?
Do you work with scientific care?

Sixty-second Annual Exhibition of the Royal Photographic Society of Great Britain, 1917.—The Council of the Röntgen Society desire to call the attention of members of the Society to the above exhibition of the Royal Photographic Society, to which the Röntgen Society is now affiliated. It is hoped that a good exhibit of radiographs will be forthcoming and entered in the class provided for scientific work.

The present opportunity, afforded by so much war work, should provide ample material for a very extensive entry of X-ray prints.

The Council, in commending this to the members, express the hope that an exhibit of work illustrating the use of the X-rays in dealing with war injuries may be forthcoming from the Röntgen Society, and be quite a feature of the exhibition.

The exhibition will be open during October and Nomevber, 1917. Further particulars and entry forms may be obtained from Dr. Knox or from the Secretary, R.P.S., 35, Russell Square, W.C.

NOTES ON BOOKS.

THE ASSOCIATION FOR THE STUDY OF THE INTERNAL SECRETIONS.

Announcement.

The object of this Association is to correlate the work and interests of many physicians and students throughout the world who are interested in the study of the internal secretions, the endocrine glands and organotherapy, and thus by concerted, co-operative effort to broaden useful knowledge in his phase of medicine.

In our last issue we announced the receipt of Vol. 1, No. 1 of the new publication Endocrinology.

This Bulletin of the Association for the Study of the Internal Secretions is to be published quarterly and arrangements have been made for *exchange* with our Journal.

In the opening article by Llewellyn F. Barker, of Baltimore, it is claimed to be the first medical journal to be devoted entirely to the study of the internal secretions. The first fifty pages are taken up by original articles by prominent members of the profession—then follow Book Reviews, and some 193 Abstracted Articles connected with the literature on the internal secretions.

Number 2 has just come to hand, and shows a distinct increase of vitality. Of course, any attempt at a review of such a work would be out of place in our journal, and the exigencies of the war having temporarily

deprived members of the use of our library the Editor will be pleased to send the Bulletins on loan to any of the medical members who may apply for them.

The extract at the head of this article is the first paragraph in the "announcement" published in No. 2, and explains the aim of the Association, further particulars of member-ship, etc., are given in the volume.

A Manual of Practical X-ray Work, by DAVID ARTHUR, M.D., D.P.H., and JOHN MUIR, B.Sc., Ch.B., and B.Sc., Capt. R.A.M.C. Second edition. Revised with 188 Illustrations. William Heinemann, London.

The first edition of this work was published in 1908; since then great advances in X-ray technique have been made; the chapter on localization of foreign bodies has been enlarged and brought up to date, and that dealing with the treatment of ringworm has been enlarged.

The striking feature upon opening the book is the number of illustrations, in our opinion many of them are unnecessary and some of them are so extremely bad; a cross-thread localizer on page 203 is little more than a blotch of ink, and many of the half-tone illustrations are inferior and fail to show the detail for which they are inserted.

As in the earlier edition, considerable space is devoted to apparatus. The introductory chapter is necessarily brief, but the story of the evolution of the X-ray tube is essentially correct, except that Crookes's investigations on the electric discharge were very much earlier than is stated.

In the chapter on diagnosis the need for a preliminary study of the normal is insisted upon, and the eighty-four pages devoted to this important subject form probably the most valuable part of the book; the reasoning is sound and masterly.

There is a short chapter on orthoradiography and the concluding section is devoted to therapeutics; here the authors admit that they are on debatable ground; the introductory cautions and notes are important and very sound. It is not within our province to discuss the authors' conclusions and suggestions for specific treatment but undoubtedly they are the outcome of much practice and careful observation, and therefore cannot fail to be of value to the profession.

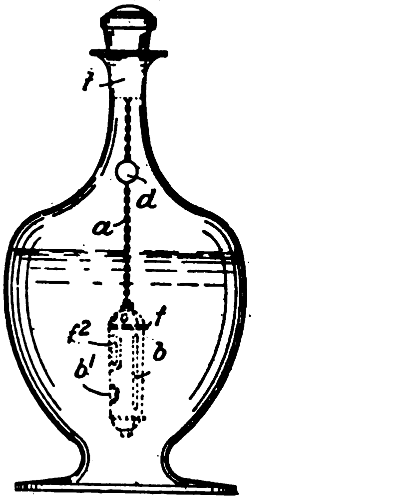
The book is well indexed but one would suggest that in a future edition it would be an advantage to delete the four pages devoted to the List of "Illustrations," and to amplify the table of contents.

Abridgment of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena. — Compiled for publication by H. T. P. GEE, *Chartered Patent Agent, 70, George Street, Croydon.*

17,092. *Röntgen-ray Photography.* T. T. BAKER, Farleigh Lodge, Warham Road, South Croydon, Surrey, Dec. 4, 1915.—In order to decrease the time of exposure necessary in taking X-ray photographs, two intensifying or fluorescing screens are used, one on either side of the negative. The screen nearest the X-ray tube is coated with very crystalline calcium tungstate which is transparent to the rays, while the screen on the farther side of the plate is coated with semi-crystalline calcium tungstate, which is more opaque to the rays.

17,781. *Radio-active preparations.* L. PAGLIANI, 21, Corso Oporto, Turin, Italy, Dec. 20, 1915.—An improved means for suspending a radium preparation in water for rendering the water radio-active consists of a stopper *t*, chain *a*, case *f* having perforations such

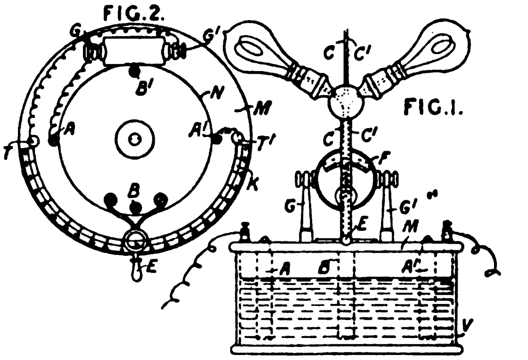
FIG.2.



as *b*, b^1, and capsule f^2 containing the radium preparation. A medal *d* is secured on the chain.

103,859. *Electric medical appliances.* E. E. GREVILLE, 167, Gray's Inn Road, London. Feb. 15, 1916, Nos. 2249, 8240 and 11,363.—An apparatus for use in the application of electricity medically comprises a liquid rheostat, Figs. 1 and 2, used in conjunction with other devices such as a milli-ammeter F and an induction coil U, Fig. 3. The rheostat consists of a vessel V containing water, in which depend two movable electrodes B, B^1 suspended from a rotatable disc N, and which are connected by leads C, C^1 to the source of current. Two other electrodes A, A^1 connected to terminals T, T^1 are fixed to an insulating slab M fixed

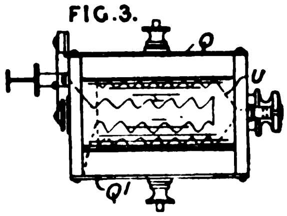
FIG.2. FIG.I.



to the vessel V, and are used for leading off a portion of the main current, the strength of which is dependent on the relative positions of the fixed and movable electrodes. Fixed to the disc N is a handle E, which, by moving over a scale K on the vessel V, indicates the voltage between the movable electrodes. Pillars G, G^1 are provided for supporting either a milli-ammeter F or an induction coil U. The primary winding of the coil is connected to metal bars Q, Q^1, which may be clamped to the pillars G, G^1 which serve to conduct the current to the coil. If the main supply is alternating, the contact-breaker of the coil is thrown out of action or the coil is made without one. Alternatively, a rectifier may be used. The apparatus may be used in conjunction with an electric lamp for illuminating parts of the patient's body. The Provisional Speci-

fication 2249/16 states that the electrodes of the rheostat are made of carbon. If the main current is alternating, the rheostat may be used as a rectifier by employing aluminium and carbon electrodes in a solution of magnesium sulphate. The escape of gas may be diminished by means of a layer of oil on the liquid in the rheostat. The current may be periodically interrupted by means of a wheel divided into insulated sections and driven by hand or motive power; or a rocking beam dipping in mercury may be used. According to the Provisional Specification 8240/16, discoloration of the water in the rheostat is avoided by placing

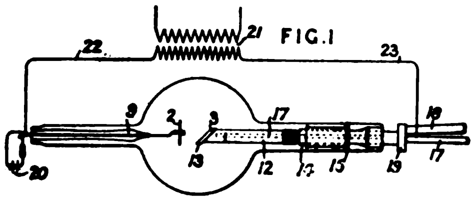
FIG. 3.



over the electrodes a bag or cover of suitable material. A rectifier for alternating currents may be used, comprising four or more cells containing a solution of ammonium phosphate, in which are immersed electrodes of carbon and aluminium or aluminium alloy. The Provisional Specification 11,363/16 states that multiple terminals may be employed for the treatment of several patients simultaneously, and that, when the four-celled bath is used, the cells may be so designed as to pack one within another.

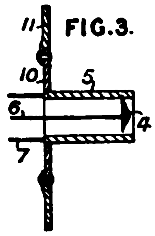
104,230. *Röntgen-ray Tubes, etc.* British-Thomson-Houston Co., 83, Cannon Street, London. (General Electric Co.; Schenectady, New York, U.S.A.) March 7, 1916. No. 3,391.—In a vacuum receptacle, such as a Röntgen-ray tube, operating with a substantially pure electron discharge independently of gas ionization as described in Specification 14,892/13, the necessary high vacuum is maintained by automatically disintegrating or sputtering electrically a metal within the receptacle in response to positive ionization of gas

FIG. 1



evolved during operation from parts of the apparatus. The initial vacuum is created by subjecting the receptacle to an exhaust to such a degree that a discharge occurs with difficulty from an unheated cathode, and then sealing the vessel and impressing on the electrodes, while the cathode is heated, a high-potential current which disintegrates suitable metal, such as copper, silver, or gold, forming part of one at least of the electrodes. In the Röntgen-ray device shown, the cathode 2, Fig. 1, comprises a spiral filament 4, Fig. 3, of tungsten connected at one end to a tungsten wire 6 and with its other end welded at a suitable position inside a tube 5 of molybdenum or other refractory metal, to which is connected a tungsten wire 7. The wires 6, 7 are sealed into a glass stem 9 and are connected to a battery 20 to heat the filament 4 to incandescence. A ring 11 of the metal readily disintegrated electrically is secured to a molybdenum flange 10 on the tube 5. The anode 3 comprises a target 13 of tungsten, a copper or like metal tube 12, and an iron tube 14 sealed into the arm of the bulb, a glass ring 16 serving to centre and support the iron tube. Water or other cooling fluid is introduced through a supply tube 17 and conducted away through a connection-box 19 and a discharge tube 18. The main operating current is supplied from a high-potential source, such as a transformer 21 connected by conductors 22, 23 to the terminals of the tube. When an alternating current is used, the cathode may consist entirely of refractory metal; the target 13,

FIG. 3.



when negative in potential, will attract positive ions of any gas evolved and ionized by the discharge, and some of the copper, etc., will be disintegrated and will precipitate or fix the ionized gas, thus restoring the high vacuum; preferably, however, both anode and cathode comprise metal readily disintegrated electrically. When the cathode comprises the ring 11, the same effect will be produced with direct current, since positive ions will be attracted to the negative terminal and disintegrate some of the metal of the ring 11. The last stages of the initial exhaust are preferably completed by a Gaede molecular pump or other exhausting device.

ABSTRACTS.

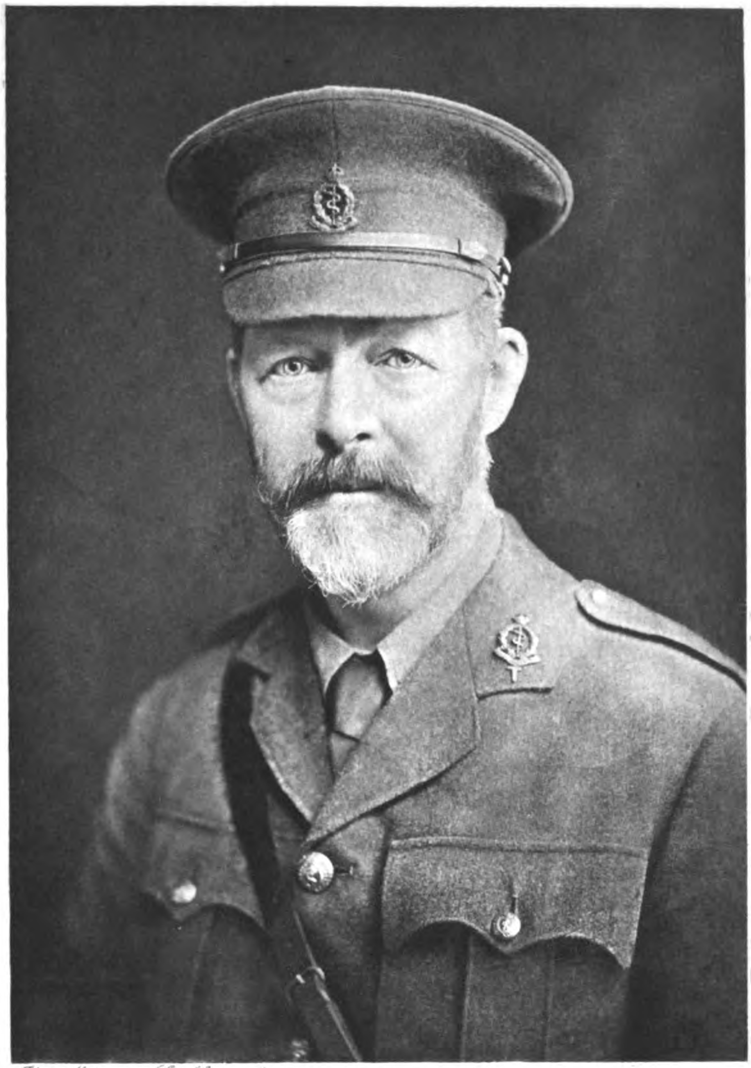
214. *Semi-transparent Mirrors.* (El. World, 68, pp. 1205-1206, Dec. 16, 1916.)—Describes the method employed in the research laboratory of the Eastman Kodak Company for making, by kathodic deposition mirrors transmitting a given percentage of light, the size of the mirrors ranging up to 11 in. square. The glass plate to be coated with the metallic deposit is supported on glass pillars parallel to and a short distance above the kathode, which consists of a thin metal sheet, usually Pt 70 per cent. Ir 30 per cent. A bell-jar encloses anode, plate and kathode, and after exhaustion the discharge is passed for a length of time depending on the current and the degree of transparency required.

A. W.

225. *X-ray Spectra of the Elements.* E. Rutherford. (Engineering, 102, p. 320, Oct. 6, 1916. Paper read before the British Assoc, at Newcastle.)—The paper contains a *résumé* of recent work carried out especially in Scandinavia and in the United States. As an introduction the earlier important work of Moseley (which contained a study of the spectra of forty elements) in connection with atomic numbers is described in detail.

The American work has chiefly been done with the tungsten antikathode, with the aid of Coolidge tubes. This work, in addition to work of a similar nature by the author, is discussed, and its connection with the quantam hypothesis clearly demonstrated. In conclusion, it is stated that the penetrating power of γ-rays from RaC is much greater than that given by a Coolidge tube at the highest practical voltage. Thus it is shown how difficult it is to measure, by any known crystal methods, the wave-lengths of penetrating radiations of such high frequency.

A. B. W.



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Captain C. Thurstan Holland.
R.A.M.C. (T.F.)
President of the Röntgen Society. 1916-1917.

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RÖNTGEN SOCIETY.

AN ORDINARY GENERAL MEETING, preceding the Annual General Meeting, was held on Tuesday, June 5th, 1917, at the Cancer Hospital (Free), Fulham Road, S.W. In the unavoidable absence of the President, Dr. G. B. Batten, Vice-president, took the chair.

The minutes of the last meeting were read and confirmed.

Mr. Philip Charles Kent was elected a member of the Society.

NOMINATIONS.

J. A. SHORTEN, B.A., M.B., I.M.S., X-ray Specialist, War Hospital, Colaba, Bombay.

Proposed by SIDNEY RUSS,
Seconded by ROBERT KNOX,

DUNCAN OTTO MACGREGOR, M.B., C.M., Medical Superintendent, Victoria Infirmary, Glasgow; Langside Cottages, Langside, Glasgow.

Proposed by ROBERT KNOX.
Seconded by GEOFFREY PEARCE.

CONSTANCE MARY BUTLER, 32, Upper Brook Street, London, W.1.

Proposed by HOWARD HUMPHRIS.
Seconded by W. HAMPSON.

CLAUDE SABERTON, M.D., Radiologist, Spring Mount, Springfield Avenue, Harrogate.

Proposed by C. THURSTAN HOLLAND.
Seconded by ROBERT KNOX.

JOHN A. E. LYNHAM, M.D., B.A., Radiologist, Radium Institute, Riding House Street, W.

Proposed by ROBERT KNOX.
Seconded by SIDNEY RUSS.

ERNEST WILLIAM REED, M.B. (Capt., R.A.M.C.), Radiologist, 4th London General Hospital, Denmark Hill, S.E.

Proposed by ROBERT KNOX.
Seconded by G. H. RODMAN.

W. CARRICK ALLAN, M.D., Senior Medical Officer, Hackney Infirmary, Homerton, E.

Proposed by ARTHUR SCHIFF.
Seconded by JAMES H. GARDINER.

L. ERASMUS ELLIS, M.D., 46, High Street, Berea, Johannesburg, S.A., Electro-therapeutist.

Proposed by GEOFFREY PEARCE.
Seconded by ROBERT KNOX.

THE FUTURE OF THE BRITISH X-RAY INDUSTRY.

(Discussion continued.)

ROBERT KNOX (Secretary): I have listened with great interest to Mr. Pearce's introductory paper and to the remarks of the other speakers, and in the main I am in agreement with them. An important discussion has been opened up and it is my hope that something tangible may result from it; the present discussion may well mark the turning point in the history of an industry which has had a chequered career in the past. It may well do so, for it has taken place at a time when, largely as a result of the great demand for X-ray apparatus in connection with the war, there has been an unprecedented run on the trade. The makers have responded well to the call, they have been working at very high pressure since the outbreak of war and as a result of all their thought and work must

have accumulated experience which will be of the greatest possible value, especially in regard to the re-organization of future business. Professor Porter expressed himself as a little dissatisfied at the suggestion of new schools of Radiology being established in this country. I do not think he need be alarmed; such schools would deal chiefly with the practical side of Radiology and would be linked up with existing centres for the teaching of the scientific sides of the subject. The medical man wants a school where the clinical and technical sides will be taught. In dealing with Mr. Wright's trenchant criticism of the British medical man, I must refer in detail to a few of the points he made. I also was at the Congress to which he refers, and I totally disagree with the conclusions at which he arrived. There was no man present at that Congress who was more honoured and respected than our past President, Dr. Deane Butcher; he could at any time and at any Congress have filled, not only the chair of a section, but could have lent dignity and weight to the chief position. No man was ever more cordially welcomed at these continental congresses than Dr. Butcher.

Our present President has attended a number of congresses at which I also was present, and I can speak from personal knowledge when I state that he might easily have been chairman of a section or even president of a congress—and I am certain that no German of the present day could more competently discharge the duties of the office than he. But a truth must here be told and an illusion be dispelled; the English or, I should say the British, radiologist attends a congress in a holiday mood and belongs moreover to so modest a class of men that he does not bestir himself to charge the air around with that radiant energy without which no man at a continental congress can hope to shine.

Mr. Wright has charged the British radiologists with lack of patriotism in going abroad and in buying foreign apparatus in preference to the home product.

Let us carefully examine this statement.

Why did British medical men go abroad? It has been a custom from the earliest days for medical men learned in this country to go abroad to the best centres of learning in other countries to study the methods followed there; a custom which I sincerely hope will never be discontinued—as Dr. Metcalfe pointed out, we go abroad in order that we may be fitted to do the best we possibly can for our patients. Medicine and science recognise no international limitations. It is unfair to state that we slavishly copied German methods; we, in common with our colleagues in other branches of medicine, visited other countries than Germany. I, for instance, have repeatedly visited France, Holland, Denmark and Austria-Hungary, as well as Germany, and have seen clinics in many of the large continental cities. My experience is also that of many other radiologists.

The result of these visits has been a familiarity with techniques which may have been developed in this country; for instance, the much advertised Freiburg treatment for fibroids had already been developed in this country on slightly different lines and results were being obtained in deep therapy which favourably compared with those obtained abroad. We did not advertise the work we were doing, however, in the same way, but just prior to the war the Germans were beginning to come to England to study our methods, particularly in relation to radium therapy. This was becoming an increasingly larger pilgrimage on their part.

In therapy we broke down so many coils in our deep work that the German manufacturer had, in self-defence, to modify the principles of coil construction, and English-made coils bore very favourable comparison with the German machine. In other words, in this country just prior to the war we were demanding from the coil and the X-ray tube more than the German manufacturer could cope with, and we were beginning to look elsewhere for our apparatus.

The result was that American apparatus and tubes were rapidly replacing the German. I would like to ask here—why American and not British?—***and I will answer the question a little later.*** The British medical man therefore

went abroad in order that he might be conversant with as many of the approved methods of treatment as possible and the result has been the elevation of British radiology to its present high standard, and I ask if it has not been worth the price ?

Moreover, the British medical man was forced to go abroad and study foreign methods for another reason, namely, that if he could not keep up with continental workers he soon found that patients went abroad in shoals to be treated at continental clinics for so-called "cures." People went abroad for treatment which could quite well be carried out at home under, it may be confessed, humbler conditions. The German people at that time were pushing in all directions and they did not hesitate to advertise their medical men and their health resorts as the best in the world. I have seen quite a number of these so-called "cures" on their return to this country, and have treated them afterwards, and often the only tangible result to be noticed was that they had spent a great deal of money for a very small return in the way of restoration to health.

I do not wish it to be inferred that no good can come out of Germany; we owe a large number of valuable discoveries in the past to the best type of German medical man, but I do assert that commercialism in medicine was very prevalent in Germany before the war.

These days will never return to Germany in the memory of the present generation, but there are other countries of a very high standard in science and medicine, and it is only by a healthy competition with these countries that the British medical men and manufacturers can hope to attain to a high position in the world's centres. Let us, therefore, concentrate all our energies in honest endeavour to attain to that position which will give us a prominent place for the future.

Mr. Wright himself confirms us in our opinion; he himself travelled to Amsterdam with the avowed intention of securing a contract to manufacture, mark you, an American machine imported into this country by way of Holland. Why was it necessary for Mr. Wright to go to Holland in order to secure the rights to manufacture a protected article ? Was there no skill in England capable of producing such a machine ?

Yet even now the fact remains that the Snook machine is the best product of its kind made in England. Mr. Wright did exactly what we medical men have done in going abroad to obtain a knowledge of all the best types of apparatus.

I must say that I greatly enjoyed Mr. Wright's companionship on the way to Amsterdam; that was the beginning of a friendship which, with a breezy interlude or two, has continued to the present time. We had a very stormy voyage—a doubt existed in my mind when the ship pitched into sight of Holland whether we might not in the heaving sea miss Holland altogether; think what might have happened if by mistake we had landed in Germany. Would he have secured the rights to manufacture in England a German apparatus ?

Mr. Wright is not quite accurate in his statement regarding English doctors. I wish he had said British—then I should have been included in his list.

Mr. Wright himself tried to introduce a German machine into England, but no one would buy it. Why ? Not because it was a German-made machine, but because it was not quite good enough for the British doctor. I myself was nearly persuaded to buy the machine, but I fortunately went to Germany before deciding and found that the maker had improved it almost beyond recognition, and what Mr. Wright was trying to sell in England had become obsolete in Germany.

I hardly think Mr. Wright or any one else can seriously expect medical men at the present time to bind themselves not to buy any foreign apparatus—a policy of that kind would soon leave us hopelessly in the rear.

No! the hall mark of success must be efficiency, and none but the very best technical apparatus can hope to hold its own in the world's markets. Let the British manufacturer put upon the market and keep putting upon the market the very best and most efficient

apparatus, and there need be no fear but that he will secure the greater part of the trade of this country. I think in the future there will be a tendency to buy British goods if they are obtainable, but let me point out emphatically that there will be no preferential treatment if the goods are not up to the standard required; we want the very best obtainable and we will have it, irrespective of where it comes from. I say this with a reservation. I sincerely hope none of us will be persuaded to buy German apparatus in the future. Should Germany produce apparatus which we must have, then I trust an English firm will manufacture it for us; tariffs will not prevent us from buying the article we want if as good cannot be got at home, nor would we hesitate to pay more for the British product if it is incomparably superior to the imported. In illustration of this point take the Coolidge tube. Can anyone here say that if this tube had been made in England its sale throughout the world would have been any less? Why do we buy Coolidge tubes at the present high price? Because they are the best tubes on the market.

Why does the price not come down? Because at present there is no rival to it.

Can England not turn out a tube which will equal or surpass it? Surely an enterprising English firm could at least secure the right to manufacture it in England.

I am interested to hear Mr. Wright speak in favour of the German medical man; his explanation of the German doctor's motives is interesting. I am afraid those of us who know something of the relations that existed between the German manufacturer and the German medical man could give another and probably not quite so patriotic explanation of the attitude of the latter.

Now let me explain how it is that so many hospital contracts in the past have been given to continental firms or their agents in this country.

You must realize that the medical man in charge of the X-ray department rarely has the final word in the bestowal of a contract. There are such things as committees of management on all hospitals, and these committees decide on all business matters. On all of these committees there are shrewd business men whose business it is to look after the spending powers of the committee. Estimates are carefully gone over, discounts are considered and, as a rule, other things being equal, the lowest tender secures the order. Prior to the war German goods could be sold in this country at a lower rate than the home-manufactured article. Hospital committees are composed of practical men rather than patriotic philanthropists, and when the home article is quoted at 25 per cent. more than an imported one then there is very little chance of the former supplanting the latter. I have had a great deal of experience in dealing with contracts and hospital committees and can assure you that there is truth in what I say.

Again, no two tenders agree in all details; some are so loosely put together that even the person who compiled them might have difficulty in coming to a decision.

Some makers quote for their own goods and say in essence that they are the best and therefore should be bought; that is not enongh for a hospital committee.

To business men let me tender this piece of advice: Cultivate up-to-date business methods, find out what your customer really wants and see that he gets it when you have the opportunity to supply him; that is the royal road to success in business.

So far my remarks have been general; I will now come to the particular.

I think there are three principal reasons for the failure of the British X-ray industry to hold its own in the past.

(1) Lack of capital.

(2) Want of co-operation.

(3) A failure to employ highly technical men to carry out contracts. Mr. Pearce has put his finger on the spot when he refers to the need for the employment of skilled technical men. Lack of capital is the chief reason; given sufficient of that and the others would automatically adjust themselves.

Why is not capital forthcoming in a rich industrial country? Because up to the time

of the outbreak of war the industry was not large enough to have an independent existence.

A short time before the war a large electrical firm was approached on this very question. The management carefully considered the matter, but eventually regretted that the prospect of the industry was not sufficiently encouraging to warrant the outlay of the necessary capital.

How has the industry been fostered abroad, notably in Germany? On the continent the industry has been fostered by several large electrical firms who, by virtue of their resources and capital, have been able to initiate research and perfect the technical details of apparatus. Yet even the figures quoted by Mr. Pearce of Germany's export trade prior to the war are not very encouraging from a financial point of view; the turnover appeared to me to be very small.

Mr. Pearce referred to the necessity for research work in this country, and I think I know exactly what he meant. Professor Porter pointed out that the facilities for research work in England are unequalled. I agree entirely with his statement; it would surprise most of us here if we realized the vast amount of research work which is carried out in England and very little said about it; we do not advertise enough, but the work is done.

What steps can be taken to ensure success in the future?

(1) A closer co-operation between the physicist, the technical expert and the practising radiologist would soon lead to an improvement in this particular direction. This point has already been fully dealt with by other speakers.

(2) An amalgamation of existing businesses into one large co-operation. Mr. Pearce has told us that several of the leading firms in America have amalgamated. I fancy the total capital of the amalgamation is somewhere in the neighbourhood of £250,000. Perhaps Mr. Pearce could tell us what turnover is necessary with such a capital to secure a profit and what the profit would be at the end of a year's business; then perhaps we might learn why X-ray apparatus is so costly.

It appears to me that combination is the only hope for the British X-ray industry, then capital might be forthcoming. Seeing in how intimate a manner the X-ray industry is linked up with the needs of the army and navy it might be possible to get the Government to subsidize the industry in the same way as it has helped other industries.

(3) The active collaboration of medical men practising radiology. Let me on behalf of the profession assure you that we are heart and soul with you in the wish to place the X-ray industry of this country in the position which it should hold, and further to state that steps are being taken to establish a British School of Radiology. This, when in full working order, should go a long way towards effecting co-operation between the manufacturer and the men who use the apparatus. Post-graduate classes should attract students from all parts and should establish in Britain the conditions referred to by Mr. Pearce as existing in Germany. Such a school would be representative of the best work being done in the country. In a suitably arranged institute there would be rooms equipped with complete sets of apparatus in working order as described by the President. In order to ensure that the apparatus would always be representative of what was being manufactured in England, it would be necessary to invite the co-operation of the manufacturers; this could readily be arranged for by the formation of a small advisory committee appointed by the Trade Association, whose duty it would be to advise the Executive Committee of the Institute on all modifications and improvements in apparatus and to arrange for their installation.

We talk freely about the need for a School of Radiology and all admit that such a school in active being would be a good thing for all concerned, but it is, I think, only fair to point out that a British School of Radiology has always existed and that this school has done much pioneer work from the very first days of X-rays. As Mr. Wright has so feelingly pointed out, these pioneers workers are honoured men amongst us. I need only mention Sir William Crookes, Professor Jackson, Sir Oliver Lodge. Following

these, men like Sir James McKenzie Davidson, Deane Butcher, Thurstan Holland, Barclay Jordan, Russ, Hall Edwards and many others have left their mark on the literature of radiology.

And on the instrumental side there are many men who deserve to be honoured amongst us. The very examples of X-ray dermatitis so evident amongst the earlier workers and still, in spite of all our precautions, likely to be evident in the future, led to the discovery of the curative action of radiations and laid the foundation of the deep therapy so much advocated on the continent prior to the war. I say, and I say it unreservedly, the foundation stone of deep therapy was laid in England. The same might be said of protection. Mr. Dean called attention to this and he has done pioneering in this direction.

The British school, like the British X-ray industry, was busy doing pioneer work during the years of development.

That school has always existed and, like the X-ray industry, it only requires stimulating to enable it to rise to a position of prominence in the world centres. Then will begin a new period of prosperity for the X-ray industry.

The great pressure in all directions of the present time will abate with the end of the war. The industry must be prepared to start out on new lines for the development of a new trade and it is only by co-operation with the school of radiology that success in the production of new models and new apparatus can be attained.

Mr. Schall referred to the danger from the American school. I do not think we need concern ourselves on this point. The American school is a strong and particularly vigorous one, whose spiritual home in the past also existed in Germany and Austria. Like ourselves, they profited by such spiritual contact, and initiated a school of their own which was rapidly overhauling, if it had not already done so, the best work done in the German schools before the outbreak of war.

The British school will be a friendly rival to the American one, and by free exchange between the two of ideas, technique and even lecturers it is hoped that they will grow into one which will be representative of the best that exists in the great Anglo-Saxon family.

Then there are the French, the Italian, the Belgian and other friendly nations whose schools must in the future draw closer to the Anglo-American schools.

In the end the combined work of all must prove the strongest possible competitor to any schools in Germany which may exist after the war.

I should like to see a close collaboration between the British schools and those mentioned, and I am certain the desire for such collaboration exists abroad. In support of this statement I may quote from two letters which I have received from Dr. Coolige and Dr. Gregory Cole; the former states—"I wish to thank you and the Council of your Society for your cordial invitation to address you, and to extend to each of you an invitation to visit our laboratories when you come to this country."

Dr. Gregory Cole, referring to a school of radiology established in America, remarks:—"The work has progressed with great rapidity and within ten days we have opened at headquarters of the Committee a rather elaborate school for training men for military X-ray service, which will doubtless be continued for the duration of the war, and I cherish the hope that after the war is over our school may continue and develop into a school which will have great influence throughout the country in the preparation of men for X-ray work in civil life. We realize that in past years many of our physicians have felt, erroneously, I believe, that the only place where X-ray instruction could be obtained was in Germany and Austria. We knew that this was not true and yet we made no effort to provide adequate opportunity for training at any of the institutions in this country. I sincerely trust that in accordance with your suggestion there may be full collaboration between this school and any schools which you may establish in England, even to the possibility of exchanging professors for certain courses during some portion of each year. In the past you have developed a vast amount of new material that would have been

of value to us, and we may have been able to contribute some ideas that would have been of value to you. Co-operation would unquestionably be of great mutual benefit."

We have all talked a great deal about the necessary steps to be taken to further the British X-ray industry—this appears to me to have been already done, for I need only quote from a letter received from the British Electrical and Allied Manufacturers' Association: "I am desired to bring to your notice the fact that a section of this Association has been formed, enrolling British manufacturers of X-ray and electro-medical apparatus, with the object of improving the status and prospects of that industry by co-operation and research.

"It is probably scarcely realized by the general public what a very important part is played in modern medical practice by X-ray and electrical methods. Every hospital of any size has now a more or less elaborately equipped department for such work, and thousands of medical practitioners throughout the empire devote their entire energies to this class of diagnostic and curative work. The X-ray examination of those wounded in the war has become a matter of routine, such examination being, in many cases, made actually on the field by the employment of a motor X-ray installation, while the subsequent treatment of convalescent soldiers by electrical methods is daily increasing in volume and importance.

"Before the war the major part of the X-ray and electro-medical apparatus used in this country was made in Germany and other foreign countries. Since 1914, however, great strides have been made by individual British manufacturers, and it is hoped that the enrolment of its members as a section of this Association will further help to place and maintain this important key industry in a position where it can supply, not only the home trade, but the whole of the Empire. British manufacturers have been at a serious disadvantage owing to lack of co-operation by which to meet the keen competition which existed in the world market. The Section is one comprising practically every manufacturing firm in the business in Great Britain, and its formation would seem, therefore, to offer a means whereby the manufacturer of British electro-medical instruments may be systematized and fostered.

"Already the Section has been able to co-operate with the government in research work connected with the improvement of some essential instrumants, and it is hoped that this will be only a preliminary to wider investigations.

"The Section views most hopefully the future X-ray and electro-medical industry in this country, and earnestly invites the co-operation of medical men and hospitals with the object of supporting and strengthening the movement towards the exclusion of foreign-made apparatus. Any practical suggestion from X-ray workers will be most gratefully considered, and the aim of the Section being to give such workers an entirely British service of everything required for their use."

I cordially agree with this letter with one exception.

Any country can only hope to capture a share of the world's trade and it would be a false step to ask medical men and others to exclude foreign-made apparatus. Trade must be reciprocative. Let us get the best from any quarter. Let your efforts be in the direction of making yours the best, that is the only way.

In conclusion, I would like to make the following suggestions:—In order to further the interests of the British X-ray industry the following might be suggested as a practical scheme:—

(*a*) The formation of an advisory committee consisting of the Physicists, Technical Experts and medical men.

This committee could act in collaboration with the section of the British Electrical and Allied Manufacturers Association.

(*b*) Co-operation between existing firms, even to the extent of an amalgamation—this would in time lead to a standardization of apparatus and would in no way impair the efficiency of the apparatus manufactured, since the quality would always be controlled by foreign competition. It would naturally strengthen the British output.

(*c*) The equipment of an institute or a number of institutes throughout the country as teaching centres, in collaboration with Radiologists—this would afford an excellent medium for publicity and the demonstration of apparatus.

(*d*) The institution of facilities for scientific research where experimental work could be carried out in conjunction with physicists and medical men. Suitable accommodation would be provided at the institutes, or arrangements might be made to make use of such laboratories as already exist in the country.

(*e*) The establishment of research scholarships in technical work and later travelling scholarships for students who give evidence of technical skill.

(*f*) Scientific training of assistants in technical subjects.

Lieut.-Colonel ROBERT WILSON, C.A.M.C., said: My excuse for rising is that my thirty years' residence in Canada may perhaps have given me a novel point of view. To my mind there is certainly something very wrong with the X-ray industry and the X-ray situation in England as it exists to-day, or, rather, as it existed before the war (for it is improving). Then what is the matter? Before we can answer Mr. Pearce's questions as to treatment, we must have the diagnosis. Is it, speaking figuratively, the nervous system that is wrong (that is to say, does the fault lie with the scientific man?) or is it the muscular system (represented by the manufacturer)? Is the effect one of peripheral paralysis, or is it a central paralysis? We all know perfectly well that in any research work which has taken place the British have been well to the forefront with their discoveries, but while the brain has been acting clearly and ably, the impulse has somehow failed to be transmitted to the muscle. We have made discoveries and allowed other countries to exploit them. We have been content to satisfy our mental aptitude and to go no further; to make the discovery, and having made it, to leave it at that, with no effort to apply mechanically and industrially what has been discovered. Why is the industrial muscle not working? Unfortunately, the manufacturers are not working for love, but for 10 per cent. or more, and I do not blame them. The manufacturer will give you what you pay him for. If there is a demand for his article he will make it. But you cannot expect your manufacturer to put on the market the very latest and most up-to-date X-ray apparatus, involving a tremendous amount of research and a large expenditure of cold hard cash, until he is sure that somebody is going to buy it. On my last visit to England in 1910 I took the first opportunity of observing the X-ray apparatus in use. At Liverpool I saw some beautiful radiographs by Mr. Thurstan Holland, who showed me his apparatus. He got beautiful radiographs, but he had to expose quite a long time. I said I was using a four killowat transformer. He asked why. I said that there was no reason, except that I got the pictures more quickly. He said that they did not need to get them more quickly. Now, if Mr. Thurstan Holland and other leaders of our profession here were satisfied to use 12-in. coils, what incentive was there for the young men to buy transformers? Why not do as they do in the States? As soon as one type of apparatus appears it is bought largely. If something better comes out, the new one is bought, and so there is an incentive to manufacturers to produce. It is the large consumer who enables the manufacturer to turn out the goods. There is thus a fault about the nervous system in that it is too modest, it does not exploit itself. There is a lack of incentive to exploit what the scientific man has made or discovered. We have lost our dye industry because we did not apply it, and our X-ray industry because we did not let our manufacturer make it. That is how we see it across the water.

What is going to be the treatment? The treatment, it seems to me, has started. If it takes a surgical operation to put a joke into a Scotchman's head, it has taken the most tremendous of surgical operations in the form of a world war to show us what it is we ought to do. But England is being wakened up. I remember in 1910, for instance, writing over here for a

catalogue of some electrical apparatus that I had heard about, and being told that the cost of the postage was sixpence! Now, in Canada and the United States you are overburdened every morning in your post with all sorts of pamphlets and catalogues. But I am getting catalogues now for nothing through the post which are issued in this country. That is really an improvement, and in its way a hopeful sign. I say that the treatment should be: let your manufacturers amalgamate. Individually they are not able to do what is done by great firms in the United States. The General Electric Company in the United States, for instance, spends 700,000 dollars a year in their research laboratories alone. They have first-class investigators on the purely scientific side and on the applied side who get large salaries. These men in the research departments do not have to worry about what is going to happen to them and their wives and children when they die (at least they do not have to worry about their wives and children; what is to happen to themselves is another matter!) The British manufacturers can initiate research on similar lines when they are amalgamated and have things standardized. Dr. Knox hit the nail on the head when he said "standardize." They cannot do it invididually. If you cannot form one large company, then form a holding company, and delegate certain parts of your apparatus to this holding company. Let it be a company which makes the X-ray tubes or certain parts of your apparatus. Let the amalgamated firms decide amongst themselves what they are going to manufacture, and pool their profits. Let each manufacturer concentrate as far as possible on some separate and standardized piece of apparatus. That is the way to get, not the trade of England merely, but the trade of the world.

On the other side of the Atlantic, when one got an English catalogue, one generally found that the prices were marked in pounds, shillings and pence. To those of us who were familiar with these things in our youth, it is not difficult to calculate in these terms, but it is always well for the manufacturer to bear in mind that the people in America think in dollars, and the people in France in francs, and the people in Germany in marks. The catalogues should be printed in the language of the country and the currency of the country in which they are to be circularized. Let the manufacturers get together—that is the important point. Then let me beg of you to start X-ray clinics The post-graduate clinics at New York, Chicago, St. Louis and elsewhere are extremely valuable. If you go on individual lines there can be no such thing as "class" or "team" work, and there is no incentive to make progress. In America there is a high degree of specialization, at one clinic they do nothing but accessory sinus work; at another they take the stomach; other men are specializing on other parts; there are specialisms within specialisms. We shall have to do this kind of thing over here if we are to have anything like a place in the sun for X-ray work and workers. I hope you will pardon me for speaking for so long, but I wanted you to know how the case appears from the colonial point of view.

Mr. JAMES H. WEBB: Mr. Chairman, ladies and gentlemen,—There is not a great deal to say on the subject raised in Mr. Pearce's very excellent paper as it has been already discussed at considerable length.

Generally the trend of the discussion which has dealt with this side of the question has emphasized the enormous part played by Germany prior to the war, and many views have been given on the best way to combat this as and when the war comes to an end. The chief of the suggestions made to frustrate the importation of German or other foreign-made X-ray apparatus has been the imposing of a duty on the imports, but I think that before we can come to any effectual decision on this subject it is necessary to consider the actual position obtaining in the industry prior to the war.

At that time there were many British firms dealing in X-ray apparatus and without casting any reflection upon any firm I may say that only two or three of these firms were in actual point of fact manufacturers. The remainder were

importers of foreign-made apparatus and in that capacity they advertised it largely, recommended it to their clients and in fact took every step possible to put such apparatus on the British market. I do not suggest for one moment that they were wrong in so doing, as it is quite possible that looking at the position purely from the financial point of view, they were far better off than if they had been entirely manufacturers.

I have mentioned this purely with the object of showing why the foreign-made apparatus was in such preponderance prior to the war, and it suggests to my mind a very simple remedy for altering such a state of things in the future by simply adopting the course of not recommending or advertising foreign-made and German apparatus.

The answer to that suggestion may be that it is a very simple remedy, but what do you propose to do when the foreign firms actually open their own branches here? In fact such a question has already been put to me by one manufacturer. Personally, I do not see why we should have the slightest fear of foreign competition, unless, of course, it is the desire to create a "ring" and thus be in the position of dictating to the purchasers, a position which I deprecate very strongly.

I am inclined to agree with the views expressed by Dr. Metcalfe when he said that the medical radiologist did not consider who made the apparatus, what was most important to him was the efficiency of the apparatus and whether it would enable him to carry out the work which he desired to do. That seems to me to be the sum and substance of the whole position. What we have got to do is not to bother ourselves about what the foreigner may or may not do, but to look to ourselves and endeavour in every way possible to manufacture the very best apparatus with the very best workmanship and best of materials. I am confident that if the manufacturers adopt such an attitude they need not worry themselves about the future or foreign competition.

This naturally leads me to the point raised with reference to laboratories and the employment of a scientific staff to make improvements in and connected with the present apparatus. Suggestions have been made on this question—one of which was to the effect that inasmuch as no individual firm was in a position to install an efficient laboratory for the purpose it would be better for all the firms to form some sort of a combine for the purpose. Now I have asked myself this question, "Is it really necessary in view of the peculiarity of the industry?" We have to consider the question from two points of view, *i.e.*, (1) the electrical side, (2) the application or the use to which the apparatus is put. The former is within the domain of the manufacturer, but the latter is almost exclusively dependent upon the user. I venture to think, that if the man in the street had heard some of the remarks on this subject which have been made in this discussion he would be under the impression that the British manufacturers had not made any improvements in the apparatus or in fact were incapable of doing so. But this is quite contrary to the truth, for I am convinced that if we could in this hall place an X-ray outfit which was produced and sold ten years ago, alongside a present-day outfit, there would be such a marked difference electrically, in efficiency and workmanship that they would be hardly recognised as types of apparatus designed to carry out the same class of work. And in what way has this change been wrought. Certainly not exclusively by the manufacturer, but by the co-operation of the radiologist with the manufacturer; indeed it is only necessary to turn to the advertisements of practically all the makers of X-ray apparatus and whenever a new instrument is advertised you will invariably see words to the effect that the apparatus has been made to the suggestion of Dr. So-and-so. In fact I am of the opinion that the manufacturers as a body should be thankful to the radiologists for the very excellent suggestions which have been made and which are still being made.

To sum up my remarks as to laboratories, it seems to me hardly necessary for any firm to equip one on the lines suggested, for what physicist is there who knows precisely what the medical radiologist requires? We have at our disposal

Intracapsular fracture of the neck of the femur.

Plate VI.

From King's College Hospital, London.

Lumbar Spine, showing evidence of old injury.

PLATE VII.

From King's College Hospital, London

Government laboratories to assist us on all electrical matters and to effect improvements which are exclusively concerned with the electrical side, but with regard to the design we are entirely dependent upon the medical radiologist for he is the only person who knows precisely the nature of his requirements.

Now I feel convinced that if the manufacturers are content to devote all their energies upon making the very best apparatus obtainable and accepting all the suggestions made by the medical radiologist in the designs, and further, if we have the opportunity of hearing from the medical men who are members of this Society, the shortcomings of the apparatus which we manufacture, we shall then be in such a position that we need not fear any foreign competition whether great or small. With regard to overseas trade, that is a question which each individual manufacturer must settle for himself.

During the discussion the point has been raised in regard to the size of the present firms and the advantages that might accrue, either by any one firm having a large factory working under ideal conditions or by an amalgamation.

The former idea is one that would possibly commend itself to several makers, but the difficulty is as to whether the demand in the future would justify the expense incurred. The suggestion of an amalgamation is, in my opinion, very unsound. From an economic point of view it is the correct thing to do, but unfortunately instead of combinations or amalgamations achieving that which economics teach us they should achieve, *i.e.*, better production on a cheaper basis in view of the more effective distribution of labour and therefore benefiting the community by being able to sell at lower rates, what we do find is the position in practice? Just the opposite. I have tried to remember or find one combination which has conferred a benefit upon the community and I have failed to do so. Again, combines or amalgamations very seldom, if ever, produce anything that could be considered beneficial to the community. All inventions are the outcome of individual workers, therefore I earnestly hope that no scheme will be evolved which will do away with individuality in the industry under discussion.

Mr. HOWARD C. HEAD said: I notice that the title of Mr. Pearce's paper is "The Future of the British X-ray Industry," but on reading through his paper and the remarks made by the various speakers at the previous meetings, I hardly think the title conveys fully the scope of the discussion. I would suggest that it is not the future of the industry we are alone considering, but rather the future of radiology, the industry being only one link in the chain and the radiologist another, but very vital link. Mr. Pearce has very ably and completely put before us the position as it obtained prior to the commencement of hostilities, and practically up to the present time, and I think nothing more need be said of our lost opportunities.

This country has produced men of genius, pioneers and inventors, but we have allowed others to make capital out of their brains and work, and been content to wait until some other country offered us a practical application in the form of a scientific instrument.

This does not altogether reflect on the British manufacture of electro-medical apparatus, but applies to practically the bulk of our industries and has been due possibly to the long period of great commercial success of this country.

We are now coming to a period when we must seriously consider the future, but it is not a time for recrimination or for looking back.

There is no doubt we have had unprecedented opportunities which have been allowed to slip by through want of initiative and organization.

We and our competitive countries started equal when Prof. Röntgen made his discovery public, and in spite of being pioneers of several valuable developments, we have not held our own.

I do not consider that blame attaches to anyone for having purchased apparatus from Germany, and we should try and emulate some of the excellent commercial traits which have brought that country great prosperity, but while we admire certain features of German commercialism and education, and perhaps adopt them, we must beware of the popular tendency

of those who have suddenly discovered our shortcomings and would wish to pervade our whole industry with German methods and lines of thought.

It may be of interest to the Society to learn that had there been no war, the X-ray apparatus of to-day obtained from abroad would have borne hardly any resemblance to that generally adopted in 1914, proving that the German was not content to sit down and wait for someone else to give him a lead, but was constantly improving himself and adopting new ideas.

We have heard so often that the German was not an inventor, but a copyist, but copyist is not the correct word; he had the gift of being able to adapt and apply the brains of others to his own commercial advantage and incidentally to the advantage or disadvantage of the world in general.

As an example of what I mean the following appeared in the daily press at the beginning of May. "This is the first occasion on which, according to published report, a ship has been sunk by a torpedo fired from a seaplane.—The Germans have thus exploited and developed the idea which was first suggested in this country," and do we not see in the Zeppelin airship a very practical adaptation of the flights of imagination of Jules Verne?

For years past those who read American and European literature could not help being struck with the absolute enthusiasm of the workers abroad, and where you have enthusiasm you must have progress, and progress means commercial prosperity; it was, therefore, only natural that men studied abroad the latest advancements and purchased their instruments from the same source, to the commercial benefit of those countries.

This does not indicate a lack of patriotism, and my personal experience has shown that many orders have only gone abroad after every effort has first been made to obtain apparatus to fulfil the desired requirements in England.

We, therefore, undoubtedly have the remedy in our own hands. Most of the previous speakers have spoken of combination. I cannot yet see a practical solution to a trade combination for pooling the results of one experimental laboratory; this would tend to kill individual initiative and competition, the latter being one of the primary methods of bringing out the best in a man, and this has been forcibly illustrated by the pre-war American and German success.

But a combination of the radiologist, physicist, engineer, both electrical and mechanical, and the manufacturer is, I believe, a big step in the right direction.

A good deal has been said about the position of the existing manufacturers in England with respect to capital and labour, but some of the suggestions put forward are of too drastic a nature to be adopted at once, and reasonable caution should be taken, so far as the former is concerned, because this is largely a question of demand and supply. I myself do not consider the industry has quite come down to passing round the hat for support, but several radiologists have stated that whether the apparatus is British or foreign, if it is what they require they must purchase it, but surely the British manufacturer is worthy of support to the extent that provided he can produce apparatus similar to the foreign article, the orders should be kept in this country, and a resolution passed to this effect. The final decision need not rest with either the manufacturer or the purchaser, but the whole question before and after manufacture could be submitted to a special committee.

I have had some little experience with labour and one has always noticed that any attempt to take the workman into one's confidence, has only led to suspicion and distrust on his part. Without going into political questions recent events in the labour market do not engender confidence, although one can only condemn, as one can only pardon, if one knows everything. A simile brought to my notice likened the British workman to the housewife at spring-cleaning time, when it is a case of "down with everything that is up and up with everything that is down."

There is no doubt that the future relation with labour is one of the most momentous and most delicate problems and requires handling with great skill, patience and sympathetic under-

standing, and if the relations between employer and employé are reconstructed it will be essential that the community represented by those who purchase scientific apparatus should realize both the responsibility and the burden of those whose position it is to employ.

I mentioned a short while ago that the radiologist was a vital link in the chain, and by this I mean that it is he to whom the industry looks for its future, and I think I might say that I consider he could render considerable aid to the manufacturer if he reported his success or non-success with a new piece of apparatus and compared his results with his colleagues who were using the same or similar type of apparatus. This would induce other men to adopt the instrument and would promote a genuine sale for a good article, and kill the sale of much of the useless apparatus put on the market, which enjoys a spasmodic flutter for a short time and then dies unlamented and unrecorded.

Again there are various pieces of apparatus designed for obtaining the same end, but constructed on entirely differing principles. It is very perplexing to the user to appreciate perhaps the finer distinctive features of construction, and often a valuable idea is lost in this way. There should be some means by which unbiassed advice is obtainable and classified records kept of results.

On reviewing the whole subject as opened by Mr. Pearce, and discussed at the last meeting, I find one very serious omission. The radiologist, the physicist and the manufacturer have been repeatedly mentioned, but the electrical engineer has been entirely omtited, and this seems the more strange when one remembers that our first president was the late Prof. Silvanus Thompson, and that we number many illustrious electrical engineers among our members, to mention only one or two—Mr. Duddell and Mr. Campbell Swinton.

We are dealing with a subject that from its very inception is an electrical proposition. Therefore, until we have the brains of the best electrical engineers brought to bear on it we cannot hope for much progress, because electricity is the foundation on which the whole science is built and developed.

X-ray apparatus presents problems which require the skill of the expert electrical engineer as well as the mechanical engineer. His knowledge of machines must be so broad that he is familiar with the characteristics of motors from 1/20 H.P. upwards and these utilized often under abnormal conditions.

The high-tension transformer up to 200,000 volts and 25 to 30 K.V.A. requires special design. The ordinary principles have to be modified; the tests required are highly involved. Precautions against high frequency surges have to be taken, abnormal loadings and phase displacement considered, etc. Or if we consider the diathermy apparatus, which although not an X-ray apparatus, is closely allied, we are aware that this instrument is practically a miniature wireless outfit, but as the engineer well knows, is utilized under far different conditions. In the one case there is a free radiating surface, and in the other this is replaced by the human body. What is precisely the difference we cannot say, but the doctor states for example that he requires more current, *i.e.*, more ampères. The problem for the engineer is—what does he really mean ? Is it not rather a question of intensity than of amount, of area and distribution than quantity. These random examples will suffice to prove my contention, that rather than omit the electrical engineer, as has been done, we must look to him for first principles and all along the line as well.

It is, therefore, apparent that the manufacture of X-ray apparatus fell into hardly the correct class of manufacturer in the early days. It was work for the expert electrical engineering firms, and not the scientific instrument makers, but this fault is being remedied.

Before making any proposals as to how the suggested combination would work, I would like to notice the steps already taken towards remedying our earlier mistakes.

I understand that some training in X-ray work now forms part of the regular curriculum of some medical schools, and Prof. Porter has told us that provision is made in many physical laboratories for training men to undertake research, and these men find their way into works.

The training colleges for electrical engineers are turning out men who are specializing in the scientific branches of electricity, and lastly, the actual manufacturers are beginning to employ these young engineers and scientists to their great advantage.

So that we are now at the beginning of a state of affairs which was never more ripe for development.

In reading the American *Journal of Rontgenology,* I was very much struck with the short notice given on our President's outspoken presidential address.

According to this journal our President said that "the man in charge of the X-ray department" should be medically qualified, well up in medical and surgical diseases, possess knowledge of certain special diseases and also, in addition should have a thorough understanding of physics, chemistry and electricity, and be capable to some extent of helping as an electrical engineer.

I do not think that man is born yet, but if ever he should be, I think by the time he had finished his training he would have qualified for an old-age pension. But by a combination of men such a degree of excellence could be obtained and could start work at once on a modest scale, and I would endorse the remarks of other speakers that perhaps this Society is well suited to form such a combination.

I suggest that a committee be formed consisting of two radiologists, two physicists, two electrical engineers, and two manufacturing engineers. I have proposed two of each branch, but for each sitting it would not be necessary for both to be present, it would obviate the possibility of one section being unrepresented. The committee would meet periodically to consider the problems which arose in the everyday work of the radiologists; to assist one branch of science by another where the interests of the first merged into the second; it would encourage inventors in all branches to submit their proposals and the practical development of these would be fully investigated; it would arrange the introduction of members of the various branches to one another with a view to the future benefit of the science generally; it would tabulate the efficiency of apparatus; it would advise manufacturers on the development of apparatus abroad, etc., and lastly, the columns of the Journal of the Society could be opened to correspondents and members be invited to write in quoting their difficulties under a *nom de plume*, and the committee could reply in the Journal giving question and answer. This, I think, would be for the mutual benefit of all members.

This is but a suggestion, but I think it would be one way of organizing our resources before the war is over, so as to be prepared to go ahead without delay when peace is declared, and prove ourselves worthy combatants in the industrial war which will inevitably follow. Our dominant policy should be construction, not destruction.

Mr. GEOFFREY PEARCE, replying on the discussion, said: Mr. Chairman, the time at my disposal does not permit me to comment in detail upon the various remarks which have been made, both at the last meetings and this meeting, on "The Future of the British X-ray Industry."

There are one or two outstanding features to which I should like to refer.

Professor Porter and Drs. Holland and Metcalfe endorsed my statement that protective tariffs could not possibly be the means of securing for us the world's markets for X-ray apparatus. The point I desired to emphasize was not so much the political aspect of the question, but the fact that, unless manufacturers produce here apparatus which is equal to, if not superior to that made abroad, they cannot possibly hope for the support of the medical profession, and my reference to tariffs referred more in particular to preferential tariffs in connection with our Oversea Domains; the argument is equally applicable there, if not more so.

In this respect I am sorry to say that I do not see eye to eye with my friend Mr. Wright; I

can hardly think that he could seriously suggest that the English medical profession should pay 10 to 15 per cent. more to help the British manufacturer, unless, and this, as I have already stated, is the most important point, they can obtain superior appliances here, and then we have ceitainly every right to expect them to do so.

This, to my mind, should be, as I stated when I opened the discussion, our aim, and I hope that the result will be a step further in that direction.

Many valuable suggestions have been put forward, and those of Dr. Knox deserve particular attention. Some suggestions are more or less revolutionary in character—and in order that these various suggestions, which have come from members who are interested in the subject from different standpoints, are not lost, I propose that this Society appoint a committee who will act in an advisory capacity with a view to determining in what particular direction the Röntgen Society can further the interests of the industry.

The committee would, I hope, survey the many helpful suggestions and criticisms which have been the outcome of this discussion, and possibly take evidence from those who are in a position to advise on these matters, so that a practical result will develop.

The President's remarks constituted a most useful survey of the situation, and contain many thoughtful suggestions. I wonder if he has modified his views upon the relation between employers and workmen, particularly when he speaks of "making them understand they are part and parcel of a going concern," in view of the events of the past few weeks and looking upon this Old Country as still being a going concern ?

There was one speaker, I regret to say I do not remember who it was, was appalled by the number of different types of localizers which he found in the instrument makers' catalogues. My only wonder is that there are not a great many more listed by the various manufacturers, and speaking personally, if I had adopted every so-called new method of localization which was put before me, I should have had enough matter to have filled an Encyclopædia Britannica. During the first twelve months of the war I had on an average at least one a day placed in front of me, and even at this advanced period of the war there are many disappointed inventors of new methods of localizing who regard the manufacturers of X-ray apparatus as a distinctly retrograde class.

Apart from anything else, I am satisfied that the discussion which we have had these last three meetings will have been useful in more than one direction. Healthy criticism is always profitable. Different classes of members have had the opportunity of stating at some length, not only their *views*, but their *grievances*, and let us hope that one result will not only be a better understanding of each other, but a better appreciation of the difficulties which each in his own particular sphere has to face, and that a very much closer co-operatios between the various interests in this Society will exist in the future, so that pre-eminence of British-made electro-medical apparatus and the future of the British X-ray industry are assured.

The CHAIRMAN moved a vote of thanks to Mr. Pearce, and that his proposal to set up an advisory committee with a view to determining in which particular direction the Röntgen Society can further the interests of the industry be adopted.

Mr. H. E. DONNITHORNE seconded, and said that he thought such a step was one of the most important the Society could take. Next to the formation of a clinic, a committee to advise on how the X-ray profession could best be furthered would be most useful.

The motion was carried unanimously.

The CHAIRMAN asked if it was the desire of the meeting that the matter should be left in the hands of the Council to arrange.

Lt.-Col. WILSON moved that it be left in the hands of the Executive, and this was agreed to.

RÖNTGEN SOCIETY.

THE ANNUAL GENERAL MEETING was then held

The minutes of the last annual meeting were taken as read.

The names of officers and Council as nominated on the ballot paper were put to the meeting from the Chair, and they were elected unanimously, with the addition of Dr. James Metcalfe to fill the vacant place on the Council.

Dr. SIDNEY RUSS read the Annual Report of the Council.

Annual Report of the Council.

The Council, in presenting the Annual Report for the Session 1916-1917, takes the opportunity to point out that in several respects the year now ended constitutes a record in the history of the Society. The membership has steadily increased during the last four or five years until now it has reached the highest point yet attained. The average attendances at the meetings also constitute a record, while, as will be seen from the Honorary Treasurer's Report, the financial position of the Society has never been better.

The papers and discussions during the meetings have reached a very high level.

The session was opened by the President, who in his address dealt fully with the important subject of the Status of Radiology and Electro-therapeutics. While admitting the valuable work that had been done in the past by amateurs he pointed out that the time had come when all hospital appointments should be in the hands of medically qualified Radiologists, who in their turn must be reliable specialists in the work. In order to raise the standard all such men should hold consulting rank and be on an equality with their colleagues on the hospital staff. As a step towards the attainment of this end he advocated the institution of teaching facilities at the Universities and Schools throughout the country and the creation of a diploma in Radiology and Electro-therapy.

The Society is under a great obligation to Captain Thurstan Holland for the energetic manner in which he has discharged the duties of the Chair. He has been unfailing in his attendance, often at great personal inconvenience.

Captain G. W. C. Kaye has been good enough to accept the nomination to the Presidency. His work is too well known to all the members of the Society to require any special mention here. We feel assured that in his hands the work of the Society will go on to increasing success in the coming session.

The financial position of the Society is extremely good. The fact that the Society was able to invest £300 in War Loans is eloquent testimony to the stability of the Society and to the business ability of the Honorary Treasurer. It is hoped in consequence of alterations in charges for advertisements in the Journal and the probable increase in membership to meet the increased cost of publication and to still further the finances of the Society. This is as it should be, for if the Society is to hold a position of influence in the future it must be in a position to expend its resources in ways which will add to its usefulness.

The Dosage Committee has met twice during the Session, important work has been instituted in the direction of standardization of the pastille of Saboraud and Noire. The Committee is in communication with Dr. Saboraud, who has kindly consented to assist the Committee in its investigations.

The December meeting was devoted to a paper by Dr. Leonard A. Levy and Mr. Harold Stenning on "Some Remarks upon Pastilles." The paper dealt very lucidly with the following points :—

1. The use of Platinocyanide of Barium for measurement of radiations.
2. Relation between degree of colour change and hardness.
3. Relation between degree of colour change and current strength.
4. Effect of filters,

and concluded with a description of a new form of radiometer.

January meeting. A Spectroscopic Investigation of some sources of ultra-violet radiation in relation to treatment by these rays, given by C. A. Schunck, F.C.S.

This was a most instructive demonstration of the ultra-violet radiation and its possibilities in practical treatment; it led to a good discussion by a number of speakers.

Dr. Batten showed a simple cross thread frame for use in localization.

The February meeting was devoted to a paper by E. E. Fourrier d'Albe, D. Sc., entitled "Some Properties and Applications of Selenium."

The lecturer gave a short historical account of selenium, the nature of light action upon it and a short description of the action produced by X-rays. The Type Reading Optophone, an instrument for converting typed letters into specific sounds, was described and demonstrated to a large meeting of members and visitors.

At the March meeting, T. Thorne Baker, F.C.S., A.M.I.E.E., read a paper on "Intensifier Screens, their physical properties and practical applications." A most interesting and instructing paper, dealing with the composition and structure of modern intensifier screens, the use of the screen and details of experimental work. The paper was full of practical points likely to be useful in practical work—it led to a valuable discussion.

Major Stowe exhibited a new screen localizer, which had embodied in it several new points.

C. A. Schunck, F.C.S., read notes on some sources of ultra-violet radiation in relation to treatment by the ultra-violet rays. This was an elaboration of his previous paper, the two together forming a valuable addition to the literature on the subject.

At the April meeting—held at the Cancer Hospital, Fulham—Mr. Geoffrey Pearce opened a discussion on "The Future of the British X-ray Industry."

The following members took part in the discussion:—Professor A. W. Porter, Mr. R. S. Wright, Sir James Mackenzie Davidson, Dr. C. L. C. Lyster, Mr. Cuthbert Andrews, Dr. Batten, Captain Kaye. The discussion was adjourned to the May meeting, and was then continued by the President, followed by Dr. James Metcalfe, Mr. P. J. Neate, Mr. F. W. Higgins, Mr. A. E. Dean, Mr. B. H. Morphy, Mr. W. E. Schall, and was again adjourned.

At the June meeting the discussion was opened by Captain R. Knox, followed by Lt.-Colonel R. Wilson, Mr. J. A. Webb and Mr. Howard C. Head.

Several resignations have been reluctantly received by the Council—wherever possible it has been the endeavour to retain on the membership list those who wished to resign in consequence of the calls of duty in connection with the war. The number of new members during the year totals thirty; two have resigned.

The Council records with regret the death of Mr. J. Wilton.

Unfortunately, for the duration of the war it will not be able to hold meetings at the Institution of Electrical Engineers, and the Council would convey to the authorities of the Institution their high appreciation of the manner in which they had been provided for, and record their thanks for the unfailing courtesy and attention of the attendants at the Institution. It will be necessary to procure a suitable meeting place for the period of the war.

The Council also desire to thank the Committee and Chairman of the Cancer Hospital, Fulham Road, for so kindly allowing the last three meetings of the session to be held at the hospital.

The average attendance for the session now ended has been close on sixty members and visitors per meeting.

The Council views with satisfaction the marked increase in the attendances at the general meetings of the last two years. It is evident that the objects of the Society are being achieved and that a much wider interest is being taken by members and the public generally in the work of the Society. This is perhaps natural at the present time when Radiography is playing such an important part in the diagnosis and treatment of wounds inflicted in warfare. Accuracy in diagnosis, particularly in the localization of foreign bodies and fractures, has been tacilifated by the combined efforts of the manufacturers and the radiologists, and it is obvious that the interests of these two groups are

intimately associated. It is hoped that in the near furute steps will be taken to still further promote these interests in such a way that future work may be increased.

There has been no difficulty in obtaining interesting and instructive papers for the meetings. Discussions of practical value have been arranged; during the last three years there have been discussions on such important subjects as

(1) The Localization of Foreign Bodies.

(2) The Protection of the X-ray Operator.

(3) The Future of the British X-ray Industry.

Practical value has accrued from each of these discussions; to show this, it is only necessary to state that the first two occupied two full meetings, while the third ran into three evenings. In this way it has been possible to gain the interest and active participation of a large number of members actively engaged in radiological work.

Many valuable suggestions and indications for future organization have accumulated. It would be a valuable outcome of the discussions, to hold at some early date a large exhibition of apparatus, radiograms, etc., whereby it would be possible to show at one meeting the accumulated experience of the last three years. It would add to the value of such an exhibition if it could be open to the public, in order to let the outside world know that the members of the Rontgen Society had been actively engaged during the war on work of national importance. Such an exhibition might very well be held at the opening meeting of the next session, provided that suitable accommodation can be obtained, and the manufacturers could see their way to exhibit apparatus which will be representative of the very best work done in England.

The time is opportune to suggest a further development of the Society. In view of the wider interests and growing practical value of the subiects embraced it would be well to consider the possibility of the Society procuring a building for its own use where, in addition to the lecture-room, a library, museum and other conveniences might be available.

This would involve the Society in increased expenditure which would have to be met by a largely increased membership. This might be achieved by a wider publicity of the aims of the Society, or it might be possible for the Society to share a building with, say, the British School of Radiology, when the two bodies with mutual interests could aid one another for the common good.

In view of the great amount of work being done in this and allied countries, it might be an opportune time to extend to the officials of kindred societies in friendly countries the honorary membership of the Society. This might be done to the extent of offering the membership to the Presidents and Councils of Societies in France, Russia, Italy, Belgium and America. It might lead to a co-operation between the Röntgen Society and those of friendly nations and would be a mark of our appreciation of the efforts our allies are making in the common cause of humanity in a struggle for the freedom of nations.

Dr. CHRISTOPHER KEMPSTER moved the adoption of the Report, which was seconded by

Mr. P. J. NEATE, and carried unanimously.

Mr. GEOFFREY PEARCE read the Treasurer's statement and the balance sheet (*this is published in a special booklet and issued to all members of the Society*).

Lt.-Col. WILSON proposed the adoption of the statement of accounts, **Mr. S. H. MORPHY** seconded, and this was agreed to unanimously.

The CHAIRMAN moved a hearty vote of thanks to the retiring Executive, to Dr. Thurstan Holland, their two Secretaries, Captain Knox and Dr. Russ, their Treasurer, Mr. Pearce, and to Mr. Gardiner, the editor of the Journal. A hearty vote of thanks was due to all the officers and Council, but especially to the five gentlemen he had named.

The vote of thanks was carried by acclamation and the proceedings terminated.

NOTES.

The Government having taken over the premises of the Institute of Electrical Engineers in the early part of the last session for the use of the Air Board, several of our meetings were held at the Cancer Hospital, Fulham, by the kind invitation of the authorities.

Arrangements have been made to hold the meetings of the coming session at the Royal Society of Arts, John Street, Adelphi.

This temporary change unfortunately deprives us of the use of our Library until after the war is over.

The Council has decided to issue an abstract of the Report, List of Members, etc., in the form of a small booklet, and the opportunity has been taken to explain the aims and advantages of the Society and other matters. This booklet is in course of preparation and will be issued to all members; it will also be widely distributed among Institutions and those interested in the Science of Radiology generally.

Detachable forms of application for membership are included, and it is hoped that members will further the interests of the Society by making use of them. The Council expects by this means to accelerate the rapidly increasing membership of the Society.

It will have been noticed that we are publishing Abstracts of recent Patents connected with the advance of Radiology; these Abstracts are very generously contributed by Mr. H. T. P. Gee, of Croydon.

A NEW X-RAY FILM.

Messrs. Austin Edwards, Ltd., Warwick, England, have introduced a genuine novelty in X-ray films by placing upon the market a film coated on both sides with sensitive emulsion.

The advantages of such a production are obvious; the celluloid is thin and very transparent to the softest X-rays and the effect of one exposure under any condition is, of course, doubled. Foremost of the advantages of films for X-ray work are their extreme portability and their unbreakableness, by their use it is possible to take any number of radiographs simultaneously.

By the use of these double-coated films there is no longer any uncertainty as to the cause of faint markings that sometimes appear upon a radiograph, for a defect in the coating is immediately recognised as occurring on one side only, while a true radiographic impression would be found on both sides of the film.

We have had the opportunity of testing these films and find them good, evenly coated and quite easy to manipulate.

The films are packed in separate black bags with a stiff card enclosed and can be used exactly in the same way as glass plates.

They are made in all sizes, at practically the same price as ordinary glass plates, and can be obtained from Messrs. Houghton, Ltd., 88-89, High Holborn, London, W.C.

THE SUNIC RECORD.

Messrs. Watson & Sons, Ltd., 196, Great Portland Street, W., have sent us the first issue of a new publication, a small booklet entitled the "Sunic Record," dealing with the progress of the X-ray industry. No. 1 occupies some twelve pages and opens with a short Editorial detailing the aims and objects of the publication, a description of the "Sunic Plate," a new "Exposure Meter" and some other novel pieces of apparatus, then follow some extracts from our recent discussion on the Future of the X-ray Industry, some photographic and exposure hints and other matters of interest to the workers in X-rays. Messrs. Watson & Sons propose to issue the booklet monthly and ask us to state that it will be sent regularly "to any of our readers who care to apply for it."

PARAFFIN WAX DRESSING FOR RÖNTGEN DERMATITIS.

A French physician, Barthe de Sandfort, last year brought out a proprietary preparation called "Ambrine" for the treatment of burns. This preparation was a secret one controlled by a company in Paris and the treatment was not as readily accessible as desired. However, Lt.-Col. A. J. Hull, R.A.M.C., reported in the *British Medical Journal* of January 13 that the results of a mixture of home manufacture in the hospital were even superior to those obtained by the proprietary preparation. Col. Hull's formula is as follows:—

Resorcin	1 per cent.
Eucalyptus oil	2 ,,
Olive oil	5 ,,
Soft paraffin	25 ,,
Hard paraffin	67 ,,

The hard paraffin is first melted and the soft paraffin and olive oil are stirred in. The resorcin is next added, dissolved in half its weight of absolute alcohol, and finally the eucalyptus oil when the wax has cooled to about 55° C. If necessary, the resorcin may be replaced by a quarter of its weight of beta-naphthol. Col. Hull adds that the application of this No. 7 paraffin, as it is called, to ulceration following frost-bite has been as successful as in the case of burns. Other uses will doubtless suggest themselves for a soft impervious casing to wounds which can yet be readily peeled off without pain or disturbance to the delicate processes of repair.

The *Journal of the American Medical Association* has recently published an extensive article dealing with the experimental aspects of this matter and giving formulæ which are proposed as superior to the one above quoted.

According to Col. Hull burns healed with rapidity; constitutional symptoms rapidly abated; pain was reduced to a minimum; scarring appeared to be obviated, or at any rate was not apparent. The need for grafting large burns appeared to be avoided. The burns healed so rapidly with healthy granulations that there appeared to be nothing to be gained by grafting. The patients were singularly free from sepsis. The conclusion arrived at from experimenting with the ambrine treatment was that mild burns healed with singular rapidity, and severe cases recovered which would have been unlikely to recover by the ordinary methods of treatment. Observers who had had large experience of burns treated by picric acid, ointments and other methods in ordinary use, were unanimously of opinion that the paraffin method was superior to the older methods. The experience of those who had witnessed the results of burns after liquid fire attacks was that the ambrine treatment would save many lives and accelerate the recovery of all burns. Severe burns of the third degree, accompanied by sloughing and in a very septic condition, have cleaned and taken on healthy repair under this treatment, after a trial of the ambrine treatment. Severe burns of both palmar and dorsal surfaces of the hands, extending to the tendon sheaths, have healed in three weeks without contracting cicatrices. Extensive burns of the flexor surfaces of

the limbs, the regions most likely to be altered by contracting cicatrices, have healed without apparent scarring. Burns of the face heal with a new healthy skin without scarring.

The application of this kind of dressing in cases of acute Röntgen dermatitis suggests itself to Röntgenologists. We have not yet had an opportunity to try this out, but in one case of chronic Röntgen dermatitis the results were very encouraging.—*The American Journal of Roentgenology,* July, 1917.

AN IMPROVED HIGH-VACUUM MERCURY VAPOUR PUMP.

By CHAS. T. KNIPP.

The diffusion pump of Gaede[1] has stimulated a number of investigators in this country to enter the field of pump design, with the result that several improvements involving new principles have been published. In a recent number of the *Physical Review* Langmuir[2] describes an improved mercury vapour

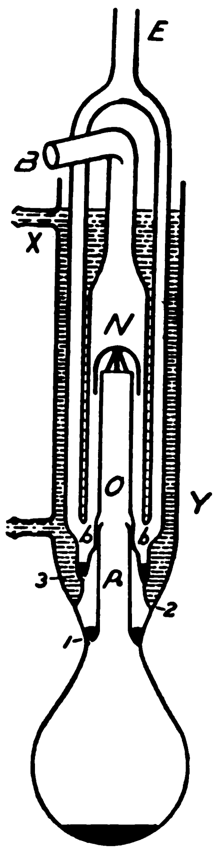


Fig. 1. An Improved High-Vacuum Mercury Vapour Pump.

pump "characterized by its extreme speed and the high degree of vacuum attainable." The writer of this note being interested for a number of years in the production of high vacua also seized upon this opportunity to aid, if possible, in simplifying the means by which vacua are produced in the research laboratory and submits the following design made wholly of glass as an improved high-vacuum high-speed mercury vapour pump.

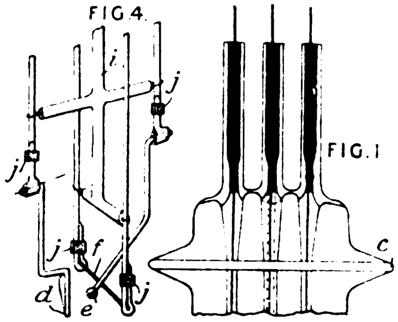
The pump complete, except the usual mercury vapour trap, is shown in the figure, which is one-third full size. The bulb to be exhausted and trap are fused to B, while the tube E is attached to the supporting or rough pump. The mercury vapour rising from the lower bulb, which is heated in a sand or heavy oil bath, streams up through the short tubes P and O and is deflected downward through an annular throat by the umbrella N. The issuing mercury vapour at once condenses on the water-cooled surface of the enveloping tube and, as Langmuir[3] pointed out, the gas that comes from B is forced mechanically downward from the lower edge of N along the cooled surface of the condensing chamber. This accumulated gas is removed through the lateral tubes b b, which unite at the top and form the exhaust tube E, all being enveloped by the water jacket XY, as shown in the figure. This construction keeps the mercury, which collects at the ring-seal 3, cool, and thus removes the objection that mercury vapour, having an *upward* velocity, would enter the annular condensing chamber. A small opening shown at 3 serves as a valve which allows the accumulated mercury to pass, yet, due to surface tension, maintains a perfect seal. The short tube P is inserted to shield the hot mercury vapour streaming up from the boiler from condensing on the surfaces at 3. The upper end of P telescopes loosely into the lower end of O, while the lower end is secured by the ring-seal 1, having also a small valve opening in it through which the mercury passes back into the boiler. By making the upper end of P conical condensed mercury vapour is caught in the annular space thus formed and automatically seals the space PO from the cavity just outside of P. The cold mercury collected at the ring-seal 3, and the adjacent water-jacket, thus have but little opportunity of cooling the hot stream of mercury vapour passing up through PO, and, furthermore, the temperature gradient between the ring-seals 1 and 2, and 3 and b b are not abrupt, hence there is no danger of the glass cracking. This construction very much simplifies the glass-blowing, since the tube throughout the process is kept perfectly symmetrical.
—*Physical Review,* April, 1917.

[1] Ann Physik, 46, 357, 1915.
[2] PHYS. REV., 8, 48, July, 1916.
[3] Gen. Elect. Rev., 19, 1060, Dec., 1916.

Abridgment of recent Patent Specifications bearing upon the subject of X-rays and Allied Phenomena.—Compiled for publication by H. T. P. GEE, *Chartered Patent Agent,* 70, *George Street, Croydon.*

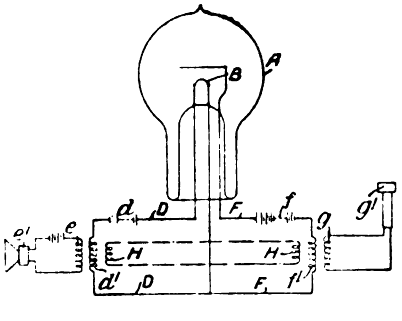
104,350. *Arc Lamps for Therapeutic Purposes, etc.* E. A. GIMINGHAM, 123, Queen Victoria Street, London. July 26, 1916, No. 1418. —Arc lamps for curative purposes and for sterilizing liquids or solids comprise tungsten or like electrodes in silica bulbs which contain nitrogen or other inert gas and can easily be opened for cleaning and for replacing the electrodes. In one arrangement, the bulb is made with a wide flange *c*, Fig. 1, which can be ground off. The leading-in wires, which are steadied by a silica frame *i*, Fig. 4, may be bent back at their ends to form eyes for the ends of the electrode stems and of a filament *l*, and are bound by clips *j*. Before insertion in the eyes, the ends of the electrode stems may be wound with a single layer of wire. Initially, the filament *l* is

heated by current, and an arc is established between it and the ball electrode *e*; the arc may be transferred from the filament to a larger electrode *d*. The bulb may be spherical or may be tubular and of small diameter, to allow of insertion in the cavities of the body. A cylindrical bulb to be placed in a vessel of liquid may



be fitted at its upper end in a sheath serving as a handle; in this lamp, the filament acts permanently as an electrode. Liquid to be sterilized may also be passed through a tube near the arc. A tubular bulb provided with a water jacket may have a wide mouth sealed by insulating-cement within a handle, from which it may be removed after unscrewing a ring placed between the bulb and handle. Specifications 2323/14 and 22437/14 are referred to.

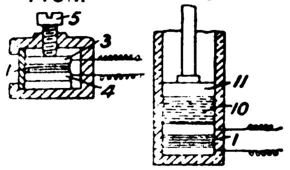
104,566. *Ionized-gas Relays.* S. G. BROWN, Edward Road, Willesden Lane, North Acton, Middlesex. March 23, 1916, No. 4335.—In a relay or detector system employing an ionized gas or an electron-discharge device, the temperature of the very fine heated filament is paried, by superposing upon a constant heating



current the current to be amplified or detected. Further variations of temperature of the filament may be produced by causing the amplified current to pass through the filament. In the arrangement shown, the filament B of a device A is heated from a battery *d*, the circuit D of which contains the secondary winding d^1 of a transformer, the primary winding *e* of which is in the circuit of a microphone e^1. The anode circuit F contains a battery *f* and the primary winding f^1 of a transformer, the secondary winding *g* of which is in the circuit of a circuit of a receiver g^1. The amplified current in the anode circuit F reacts on the circuit D, since a portion of this current passes through the filament B, while a transformer connection such as H may be placed between the two circuits D, F.

104,688. *Serum, etc; Electric Endosmose.* ELEKTRO-OSMOSE AKT.-GES. (Graf Schwerin Ges.), 185, Hanauerlandstrasse, Frankfurt-on-Main, Germany. March 7, 1917, No. 3384. *Convention date, March 7, 1916. Abridged as open to inspection under Sect. 91 of the Act.*—Serum and similar mixtures are purified by electric endosmose between diaphragms, of which the one in front of the cathode is neutral or feebly electro-negative, being made, for instance, of vegetable substance, parchment, or viscose, while the one before the anode is electro-positive, suitable materials being animal skin and chrome leather. A low electric pressure is first employed, when acids and bases, together with extractives, migrate through the diaphragms. Globulins are precipitated in the middle compartment, and may be separated centrifugally before further treatment of the serum. A higher electric pressure may then be applied, causing migration of albumens and precipitation of fatty bodies and substances resembling cholesterol. This stage of the process may be assisted by addition of an alkali or organic base. The liquid in the electrode compartments is preferably frequently exchanged for fresh water during the process.

104,861. *Selenium Cells.* F. C. BROWN, Iowa City, Iowa, U.S.A. May 4, 1916, No. 6411. *Convention date, March 7, 1916. Abridged as open to inspection under Sect. 91 of the Act.*—Selenium crystals for use in cells are produced by the sublimation of selenium



vapour either in a high vacuum or at atmosphere pressure. The selenium vapour may be mixed with argon, neon, helium or other gases, either separately or in combination; or crystals formed in an atmosphere of selenium vapour are afterwards allowed to absorb any one or a mixture of the gases stated above. The selenium cell comprises one or more crystals 1, Fig. 1, placed between electrodes 3, 4 and adapted to be subjected to pressure by a screw 5. In the arrangement shown in Fig. 3, the crystal 1 is placed in a liquid or semi-liquid 10 and subjected to pressure by means of a plunger 11.

ABSTRACTS.

The following are selected from the current numbers of "SCIENCE ABSTRACTS" as likely to be of special interest to members of the Society, and are published by permission of the Editors of that Journal.

261. *The Radiographic Efficiency of the Coolidge X-ray Tube.* W. S GORTON and J. A. C. COLSTON. (Am. J. of Röntgenology, pp. 3-8, Aug., 1916.)—It is generally assumed that the Coolidge tube does not give as good pictures as are obtained with the ordinary form of X-ray tube, and the reason, if any, assigned for this state of affairs has been the broadness of the focus of the Coolidge tube. In spite of this unfavourable

verdict it seemed worth while, in view of the advantages offered by the Coolidge tube, to make a thorough investigation of its radiographic properties in order to determine precisely its efficiency as a radiographic agent, and also in the hope that a method of manipulation might be found which would place it on a par with the ordinary type of tube for radiographic purposes. The apparatus used was a 10-k.w. transformer, a 7-in. tube of the ordinary type with a tungsten target, and a Coolidge tube of the medium focus type. This type was used instead of the fine focus type, because the tube had been previously purchased for both radiographic and treatment purposes. The field of work was limited to the kidney, since pyelography is a difficult branch of radiography, and if it should be found that the Coolidge tube is suited to pyelography then it certainly should be suitable for less deep-lying structures. The plan of the work comprised exposures with the Coolidge tube on patients of various thicknesses under various conditions of current, spark-gap, and time of exposure, with and without a compression diaphragm, and with and without an intensifying screen; also some exposures with the ordinary type under various conditions. The outstanding result is that, on the average, the Coolidge tube gives as good pictures as does the ordinary type of tube used heretofore. The best pictures obtained are not quite as good as the best obtained with the ordinary tube, but the difference is very small. Better pictures are obtained with the use of a compression diaphragm than without one, and better results without an intensifying screen than with one. A surprising feature is the amount of time required for the exposures. For the same value of spark-gap and current through the tube the Coolidge tube is found to require an exposure two or three times as long as that required by the ordinary type of tube. This means that the ordinary tube under the conditions specified gives out a far larger quantity of X-rays than does the Coolidge tube. This does not mean that the latter is less efficient as a producer of X-rays; the condition is almost certainly due to the characteristics of the milliammeter. This instrument indicates an average value of all the instantaneous values assumed by the current. Now, in the Coolidge tube the current cannot increase more than a certain amount, whereas in the ordinary type there is a rough proportionality between the current and the voltage. The result is that in the ordinary tube a larger proportion of current passes when the voltage on the tube is high, thus producing a greater quantity of X-rays than is the case when the current has a limiting value. A. E. G.

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390. *Limit of Spectrum in the Ultra-violet.* T. LYMAN. (Science, 45, p. 187, Feb. 23, 1917.)—Describes briefly a continuation of previous work. [(Abs. 778 (1916.)]. The general design of the spectroscope has not been changed, but the 100-cm. grating has been replaced by one of 50 cm. radius, thus halving the light-path and considerably reducing the volume to be exhausted. The design of the quartz discharge tube has been altered so that the end of the capillary can be brought much nearer the slit of the spectroscope, and the p.d. of the transformer has been considerably increased. Using helium at one or two mm. pressure, the nett result of these changes is that the spectrum has certainly been extended from 600 to the neighbourhood of 510 Å.U. A trace of a line was found on one negative near 450 Å.U., but it is too faint to afford trustworthy evidence. Wood's miniature arc *in vacuo* and a variety of vacuum spark arrangements have been tried, but none of these sources appear to yield lines in the most refrangible region. A. W.

501.—*Triboluminescence.* A. IMHOF. (Phys. Zeits. 18, pp. 78-91, Feb. 15, 1917.)—The research here dealt with is a contribution to the knowledge of triboluminescence in general. The results may be summarized as follows:—(1) For each substance there is a specific minimum crystal size, for which it may just be brought to luminescence. This size is the smaller the greater the brightness of luminescence, and lies between the approximate limits 0·002 and 4 mm. diam. (2) The intensity of triboluminescence is a function of the temperature of the substance, in the sense that the brightness at higher temperatures is smaller than at lower, but the curve at a certain low temperature falls again. The changes in brightness for different substances are of altogether different magnitudes. Temperatures were employed varying from a red glow to —80°C. (3) Triboluminescence with phosphorescent substances is hardly affected by temperature, and can therefore be observed if the phosphorescence approximately vanishes on heating the substance. (4) About ninety inorganic substances were tested, and 25 per cent. of these were found to be triboluminescent. A number of minerals and amorphous substances were also dealt with. (5) Almost all inorganic double salts, which are sulphates of potassium or ammonium (probably also of the other alkali metals) and some other metal are triboluminescent, and all those which are chlorides of these metals are not triboluminescent. (6) In general the rule holds that chemically similar inorganic salts behave in the same way as regards triboluminescence. A number of such groups have been obtained. (7) The elements themselves are probably not triboluminescent. (8) Salts of similar general chemical composition, but with different amounts of water of crystallization, behave like altogether different substances with respect to triboluminescence. Almost invariably the highest hydrate is triboluminescent, but other cases also occur. (9) Triboluminescence is not confined to crystal substances, but is shown also by a small number of amorphous substances which also exist in crystal form. (10) A table is given of eighty-eight substances, with the corresponding triboluminescence colour. In about 47 per cent. the colour is blue; in 25 per cent. yellow or orange; it is seldom violet and very seldom red or white; red is only found with minerals. (11) The colour of triboluminescence is dependent on the temperature to a certain extent.

A list is given of recent papers on the subject. A.W.

506.—*Absorption Coefficients of High-frequency X-rays.* S. J. ALLEN AND L. M. ALEXANDER. (Phys. Rev. 9, pp. 198-204, March, 1917.)—The work of Rutherford and Barnes on the absorption of "hard" X-rays is criticized on the grounds that their measurements of the absorption coefficients of the "end rays" only represent a certain "average" and not the hardest components. Experiments are now described in which measurements have been made, at a voltage of 120,000 of the absorption coefficients of the X-rays from a Coolidge tube after filtering through various elements. These absorption coefficients show clearly the presence of the K-radiation of Pt, Au, Pb, and Bi. With a tin filter the values of the absorption coefficients for the "end-rays" show harder rays than any that have been published up to this time, the value of λ/ρ for Al being 0·12. Experiments show that scattering is most marked in the case of elements of low atomic weight. A. B. W.

554.—*New Coupling of Induction Coils.* A. J. DE BEAUJEU. (Archives d'El. Médicale, 25, pp. 120-127, March, 1917.)—Induction coils in parallel or series offer no advantage in the production of X-rays, the intensity in the tube being very nearly the same, and there are certain difficulties to overcome. The most useful combination is a mixed one—primaries in parallel, secondaries in series. The arrangement here described enables one to obtain an increase in the intensity in X-ray tubes. The system is based upon the following considerations: The max. effect is produced when induction coils are used with mechanical turbine interrupters. This maximum is characterized by a certain ampèrage in the primary, and the best number of interruptions per second of current, which number varies between 40 and 130 about, according to circumstances. If this number could be doubled or trebled, etc., then the intensity in the tube would be likewise doubled or trebled, etc. With the coils in use this is not possible on account of magnetic, self-induction and hysteresis effects, which require a certain time to produce. There is thus time wasted between the interruptions. Apparatus and coupling is described to overcome this difficulty and various diagrams are given to illustrate the methods employed. By the means described, several coils can be worked with one mechanical interrupter, and, by the aid of suitable valves, etc., the secondary current can be conveyed into a single tube so as to obtain an intensity in proportion to the number of coils used, or into several tubes simultaneously. A. E. G.

632.—*Black Photographic Images produced by Kathode Rays.* M. WOLFKE. (Phys. Zeits. 18, pp. 128-130, March 15, 1917.)—It is well kuown that kathode rays can produce two entirely different effects when they fall on a photographic plate. For short exposures the part of the plate on which the rays fall is blackened: for lengthy exposures a kind of "solarization" (see T. Retschinsky, Jahrb. d. Radioakt, 13, p. 75, 1916), or photographic reversal, is obtained. The author considered that in obtaining photographic records of deflections of kathode rays (*i.e.*, parabolic paths on the plate) short exposures would result in sharper and blacker photographs. Experiments have been made to determine the best conditions for obtaining such clear photographs, with the following results: (1) There must be a direct connection between one of the two electrodes (deflecting the rays) and the case of the camera; (2) the pressure must be the lowest possible, not only in the camera but also in the discharge-chamber itself; (3) a high discharge voltage is essential. A. B. W.

669.—*Change of Conductivity of Minerals by Illumination.* T. W. CASE. (Phys. Rev. 9, pp. 305-310, April, 1917.)—Besides selenium, stibnite and cuprous oxide, certain other substances show an instantaneous response to varying illumination. Over 150 crystalline minerals were examined by exposing them to intermittent illumination from an arc lamp while in circuit with 110 volts and a three-step audion amplifier. The effect was judged by the loudness of the musical note corresponding to the frequency of interruption. The new light-sensitive substances thus discovered are: Iodynite—AgI—, silver oxide—Ag_2O—, the simple sulphides of Bi, Mo, Ag and Pb, and certain compounds of either Pb or Ag with sulphur and either Sb or As, known as pearceite, miargyrite, jamesonite, boulangerite, bournonite, pyrargyrite, proustite, stephannite, and polybasite. Bismuthinite—Bi_2S_3—is classed as "very good," though its resistance is over a megohm, in mm.-cube. E. E. F.

785.—*Secondary Effects of X-rays.* F. VOLTZ. (Phys. Zeits. 18, pp. 185-186, May 1, 1917.)—In a paper bearing the same title [see Abs. 136 (1917)] the author has shown that certain peculiar secondary effects observed in the "fluormetric" measurement of the hardness of X-rays were attributable to the selective absorption of the emulsion. The results obtained by using fluorescent screens were appreciably influenced by the composition of the fluorescent material.

Subsequent experiments have been carried out with three kinds of screen: (1) Barium-platinocyanide screen, (2) an "Astral" screen, and (3) an "Ossal" screen. Remarkable differences in relative brightness are observed when the three screens are illuminated by X-rays of different penetrating power. A. B. W.

815.—*New Composition Opaque to X-rays.* ANGEBAUD. (Archives d'El. Médicale, 25, pp. 216-220, May, 1917.)—The essential feature of a radiological installation is a screen for the tube which effectively limits the field of operation of the rays. Attempts to produce such a screen have been made by incorporating with glass or ebonite certain salts opaque to the rays, but unfortunately the results obtained have not been satisfactory, as the quantity of salts used has to be strictly limited, since when beyond a certain proportion is present the composition obtained is no longer homogeneous and, in the case of certain rubbers, disintegrates with time. A composition has now been found in which the amount of salts contained is very great, and it is claimed that this new substance possesses the following properties:—It is very opaque to the rays, 9 mm. being more opaque than 2 mm. of lead; it is not brittle; it is opaque to light; it is very light compared with those in use of the same opacity; it is regular in thickness and easily workable; it is a good insulator at both high and low tensions, and it is not expensive. Photographs showing comparative experimental results are given. A. E. G.

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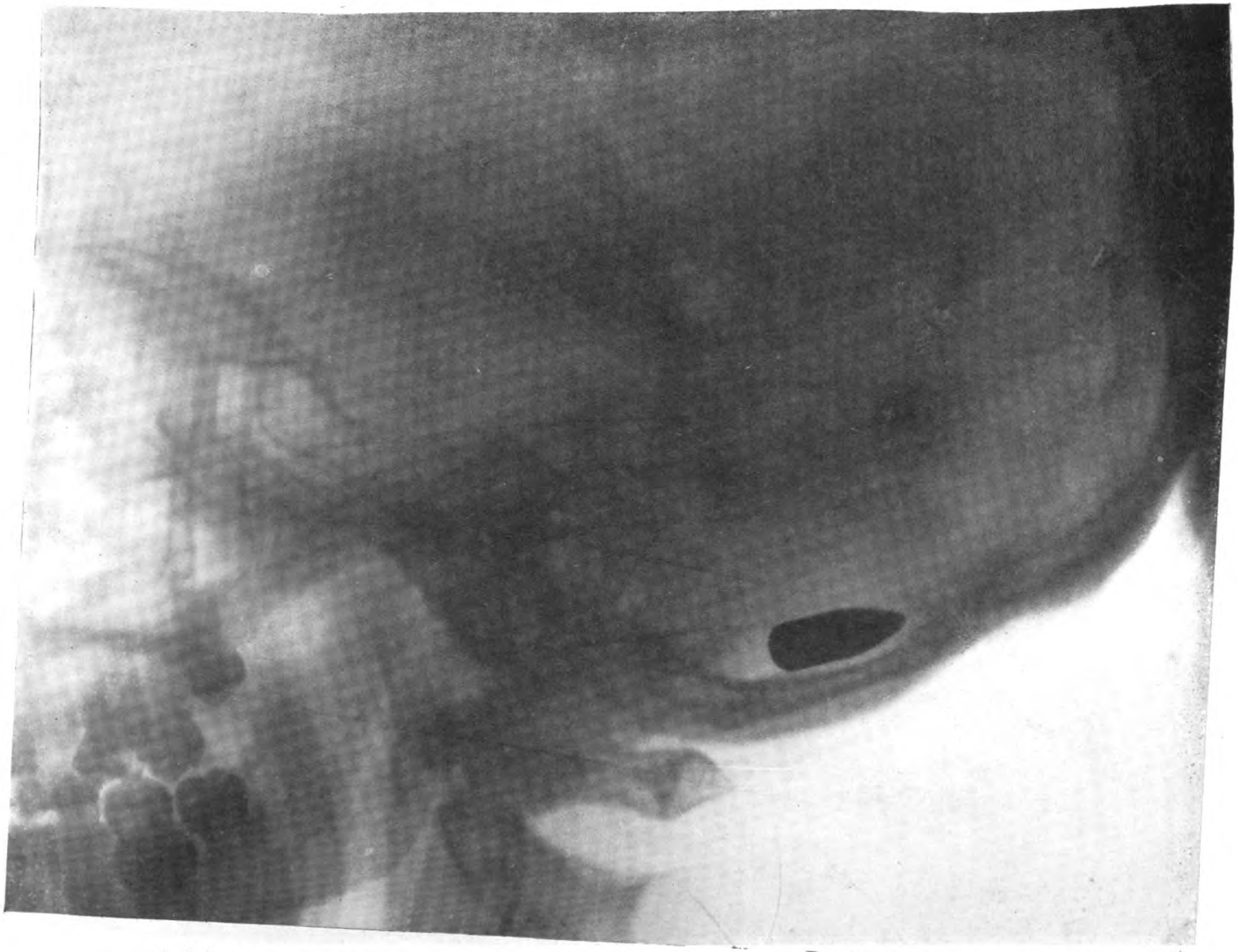

2. Bullet inside skull to one side of, and behind, the foramen magnum. Entrance wound on the vertex of the skull in the midline.

PLATE I.

SYMPTOMS.—Several months after the injury—some headache, nothing else. Bullet not removed.

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3. Bullet in right side of brain. Entrance wound on left side—shown in radiograph. Coin on right ear. Taken 1 year after the injury.
SYMPTOMS.—Forgetfulness. Slight occasional attacks of loss of consciousness. No headache.

PLATE II.